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PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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THE INSTITUTION OF ELECTRICAL ENGINEERS

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THE AMERICAN

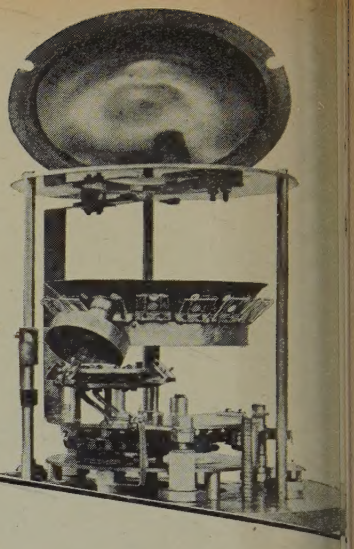
INSTITUTE OF ELECTRICAL ENGINEERS

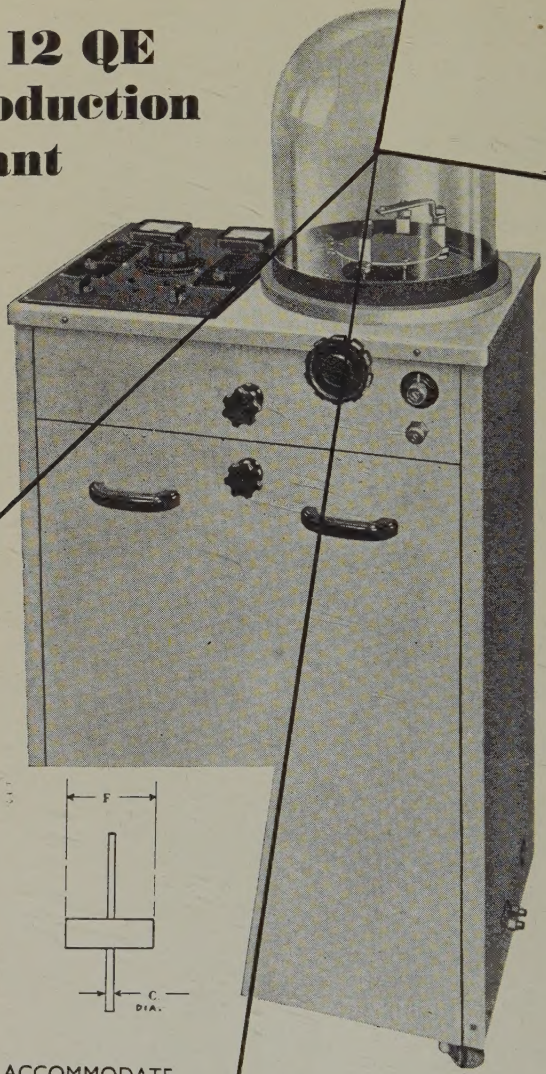
ABSTRACTS 2340–3196

VOLUME 55 APRIL 1952 NUMBER 652

QUARTZ CRYSTAL COATING UNIT

Model 12 QE High Production Plant



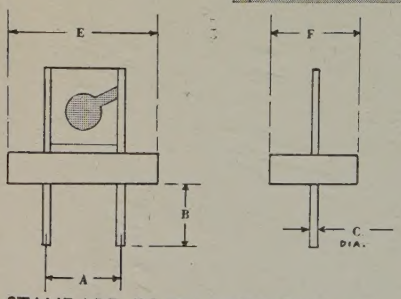


This new equip ment possesse several outstand ing desig features, such as

- A high deposition rate and e of control which permits the fi adjustment of crystals already b coated, or the complete coat and final adjustment *in one cycle*
- Frequency readings can be tak at any time during the coating.
- A turret head is designed to accom modate a number of crystals whi are rotated into calibrating positi by an externally controlled dri

(INSET ABOVE)
Photograph of turret head of Model 12QE w cover removed from work-chamber.

(CENTRE)
Model 12E; the basic unit of the 12QE in the fo suitable for the production of coated optics, fra surface mirrors, rectifiers, photo-cells, pla forms, shadow casting, etc.



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RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Mechanical testing
Non-destructive testing
Industrial radiography
Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
Applied electrochemistry
Photocells
Thermionic tubes
Cathode-ray tubes
X-ray tubes
Amplifiers
Radiocommunication
Mechanical engineering
Illumination
Metallurgy

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 53 (1950) and the Supplements published with the Indexes to Volume 53 (1950) and Volume 54 (1951). Reprints of the List of Journals (1950) and the Supplements (1950, 1951) can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Journals marked * are not received regularly.

**Amer. Soc. Metals Prepr.*	*American Society of Metals Preprint.* [Abstracted by Metropolitan-Vickers Electrical Co.]
Ann. Univ. Turkuensis A	*Annales Universitatis Turkuensis. Ser. A: Physico-Mathematica-Biologica.* Turun Yliopiston Kirjasto [Bibliothèque de l'Université], Turku.
Atomic Energy Res. Establ. [*Harwell*] *Rep.*	*Atomic Energy Research Establishment* [*Harwell*] *Report.* H.M. Stationery Office, Kingsway, London, W.C.2.
**Geophys. Mag.* [*Tokyo*]	*Geophysical Magazine, Tokyo.* [Abstracted by *Meteorological Abstracts*].
Geophys. Mem. Meteorol. Off. [*Lond.*]	*Geophysical Memoirs. Meteorological Office* [*Air Ministry*]. H.M. Stationery Office, Kingsway, London, W.C.2.
Prof. Not. Meteorol. Off. [*Lond.*]	*Professional Notes. Meteorological Office* [*Air Ministry*]. H.M. Stationery Office, London, W.C.2.
Swedish State Pwr Board Publ.	*Swedish State Power Board Publications.* Kungl. Vattenfallsstyrelsen, Karduansmakareg 8, Stockholm C.

Changes of Address

Bull. Soc. Belge Elect.	*Bulletin de la Société Belge des Electriciens.* 1 Place du Trône, Brussels.
Electro-techniek	*Electro-techniek.* Koninginnegracht 64, The Hague.

NOTE ON THE UNIVERSAL DECIMAL CLASSIFICATION SYSTEM

The abstracts are classified by subject according to the Universal Decimal Classification, and arranged in order of their U.D.C. numbers, which are printed at the head of the Abstract on the right.

The complete tables of the 4th International Edition of the U.D.C. are in process of publication. The following Parts are now available from the British Standards Institution, 24 Victoria Street, London, S.W.1.

Vol. 1, Part 1: General Introduction; Auxiliary Tables; Class 0 Generalities. Price 7/6 net.

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Abridged tables of certain sections were published with the January (1949) issues of *Science Abstracts*, by permission of the British Standards Institution, and a few reprints of these tables are available from The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

The U.D.C. numbers of the main sections of *Science Abstracts* are given in the Contents List each month.

Symbols used in the U.D.C.

: links numbers denoting subjects dealt with in relation to each other in the article.

/ indicates extension over several numbers (e.g. 535.41/.43 represents 535.41 to 535.43 inclusive).

( ) signifies Place (e.g. (485), in Sweden).

– is used to attach special analytical subdivisions applicable to certain sections (e.g. –31, ultra-violet; hence 535.34–31, ultra-violet absorption).

.0 indicates other analytical subdivisions applicable throughout Sections 53/59 (e.g. .08, measurement, hence 536.63.08, measurement of specific heat).

. Numbers are normally divided into groups of three digits by stops for convenience.

The initial "A" is used to indicate an abstract prepared from the summary published with the article.

If no indication of language is given in the abstract, the article may generally be assumed to be in English. This does not necessarily hold, however, for abstracts reprinted from elsewhere.

MATHEMATICS 51

513.811 : 530.1

2340. Reflections on a finite approximation to Euclidean geometry. Physical and astronomical prospects. G. JÄRNEFELT. *Ann. Acad. Sci. Fennicae, A I, No.* 96, 42 *pp.* (1951).

A geometry of a plane with a finite number of points is constructed by means of Galois fields of residue class modulo p, where p is a prime. It is shown that if $p \to \infty$ in a suitable manner, the geometry approximates to that of a convex domain of a Euclidean plane. It is conjectured that such a finite geometry may have applications in fundamental physical theory. R. A. NEWING

517.947

2341. A special type of group displacement for use in the relaxation technique. R. H. WOOD. *Quart. J. Mech. Appl. Math.*, **4**, 432–8 (*Dec.*, 1951).

The method discussed can speed up considerably the arithmetical work, compared with the usual method. L. S. GODDARD

517.947

2342. Graded nets in harmonic and biharmonic relaxation. D. N. DE G. ALLEN AND S. C. R. DENNIS. *Quart. J. Mech. Appl. Math.*, **4**, 439–43 (*Dec.*, 1951).

Graded nets [Abstr. 1204 (1945)] are here incorporated into the relaxational technique for solving the biharmonic equation. L. S. GODDARD

517.947 : 539.153

2343. A numerical variational method. R. E. MEYEROTT, P. J. LUKE, W. W. CLENDENIN AND S. GELTMAN. *Phys. Rev.*, **85**, 393–400 (*Feb.* 1, 1952).

A procedure applicable to the solution of linear partial differential equations of second order is described with special reference to an application to the calculation of the wave function for the $1s2s$, ^3S state of Li II [Abstr. 2921 (1952)]. The procedure has features in common with Southwell's relaxation method but differs from it by being formulated as a special case of the Ritz variational method. The energy parameter for the ground state of a term system which is obtained in this manner is always higher than the true one, a circumstance having a well-known convenience in the comparison of calculation with experiment. For comparable accuracy of the wave function the numerical work is somewhat larger, however, than in the relaxation method. The errors caused by the finiteness of the number of numerical operations are studied in simple cases, and they are compared with those of Hartree's procedure for integrating ordinary differential equations of second order. In the application to Li II only a correction to the wave function is calculated numerically; the modifications of the general method required in this case are discussed. A.

518.2

2344. Tables of the exponential function e^x. *Nat. Bur. Stand., Appl. Math. Ser. No.* 14, 538 *pp.* (1951).

Third edition, superseding MT2. Ascending exponentials: 0·0000 (0·0001) 1·0000 (18 Decimals) (0·0001) 2·5000 (0·001) 5·000 (15 D) (0·01) 10·0 (12 D). Descending: 0·0000 (0·0001) 2·5000 (18 D). Ascending and descending: 0·000000 (0·000001) 0·000100 (18 D); 1 (1) 100 (19 signif. fig.); at decimal intervals from 1×10^{-10} to 9×10^{-7} (18 D). Values of e and $1/e$ (2 556 D).

518.2

2345. Calculation of χ^2 for a 2×2 table. B. WOOLF. Letter in *Nature* [*Lond.*], **168**, 1087 (*Dec.* 22, 1951)

518.5 : 519.24

2346. The application of electrical counting to the compilation of frequency distributions and correlation tables. A. R. KASSANDER, JR AND D. W. STEBBINS. *Trans Amer. Geophys. Un*, **32**, 341–6 (*June*, 1951).

An electrical-mechanical tabulator is described which presents statistical data in array form immediately on the conclusion of a test, thereby eliminating the time-consuming process of measuring and transferring data from tape records. The basis of operation is to cause differential relays to direct a sampling pulse to appropriate counters representing different class intervals of the variable being examined. Thus the number of counts in each counter is proportional to the length of time that the variable was in a particular class interval. In its present form, the instrument is capable of presenting a nine-class frequency distribution for one variable, a twenty-five-cell correlation diagram for two variables, or six tetrachoric correlation diagrams for four variables. A.

518.5 : 621.316.313 : 621.392

2347. A direct-current network analyzer for solving wave-equation boundary-value problems. G. W. SWENSON, JR AND T. J. HIGGINS. *J. Appl. Phys.*, **23**, 126–31 (*Jan.*, 1952).

The analogy between the difference equations of a wave-equation boundary-value problem and the current-law equations of a d.c. network is developed. This theory permits construction of a d.c. network analyser for solution of the wave equation. Some of the network parameters are necessarily negative. These "negative resistors" are simulated by active d.c. circuits. The determination of characteristic frequencies, characteristic functions and response to simple harmonic forces is illustrated by solution of an irregularly-shaped membrane. Methods are discussed for solving problems involving inhomogeneous or anisotropic media or various types of boundary conditions. A.

518.5 : 621.316.8 : 621.317.79

2348. A new resistor network for the integration of Laplace's equation. E. PERSICO. Note in *Nuovo Cim.*, **9**, 74–89 (*Jan.*, 1952).

This paper develops the theory of an improved type of resistor network, for the numerical calculation of a harmonic function (in two dimensions, or in three with axial symmetry) with given values on the boundary. The advantage of this type of apparatus over those hitherto described is that it takes into account

terms of a higher order in h (h = side of the mesh), so permitting a much better accuracy with the same value of h. It is shown that, also for the usual type of network, the reasoning based on the analogy with the electrolytic tank is misleading, and that the correct method of calculation leads, in the case of axial symmetry, to values of the resistances which, in the vicinity of the axis, differ by an appreciable amount from those adopted by previous authors. A method is indicated for imposing the boundary condition on a curved line not passing through the junctions of the network. A.

518.5 : 621.317.79 : 621.318.572

2349. Calculating machines developed in Sweden. S. EKELÖF. *Trans Chalmers Univ. Techn.* [*Gothenburg*] *No.* 116, 26 *pp.* (1951) *In French.*

A non-detailed review, with the basic principles of operation briefly outlined. A digital relay computer "BARK" working in conjunction with teletype equipment has been completed and tested: multiplication takes 250 msec, addition and subtraction 150 msec, and the resolution of a symmetric system of linear equation with 28 unknowns takes 5 hr. An electronic machine is under construction with speeds ~1 000 times greater. Mechanical and electronic differential analysers exist, and also machines for calculating Fourier transforms, and performing analysis and synthesis. The electrolytic tank is in use for aerodynamic and electron trajectory problems.

A. J. KENNEDY (R)

518.5 : 621.318.572

2350. An electronic digital recording machine—the SETAR. N. T. WELFORD. *J. Sci. Instrum.*, **29**, 1–4 (*Jan.*, 1952).

The serial event timer and recorder (SETAR) was developed for use in experimental studies of human performance. The SETAR records "events" and the time intervals between them, in sequence and in a digital form, on standard teleprinter tape. An "event" is defined as the making or breaking of one or more of the input circuits. Recordings can be made from any apparatus capable of providing such "events." The machine and its principles of operation are described. A.

518.5 : 621.318.572

2351. The Binac. A. A. AUERBACH, J. P. ECKERT, JR, R. F. SHAW, J. R. WEINER AND L. D. WILSON. *Proc. Inst. Radio Engrs*, **40**, 12–29 (*Jan.*, 1952).

The Binac was the first high-speed electronic digital computer of its type to be completed. It consists of a main computing section, input-output equipment and a mercury delay-line memory of 512-word capacity. The Binac is well adapted to any type of general mathematical computation. It is a combination of a few basic circuits. Extensive use is made of crystal diodes in switching or gating circuits. These circuits fall into 3 basic classifications: function tables or diode matrices, used for converting coded groups of signals such as instructions into corresponding but differently coded groups of signals to operate switching circuits; switching gates, which control the flow of information in accordance with signals received from function tables or similar sources; and reshaping gates, which reshape signals that have become distorted in electric delay lines or other circuits. Crystal gates are used with electric delay lines to form a serial binary adder. A one-word register is formed by combining an electric delay line with appropriate reshaping gates, input and output gates and amplifiers, all connected to form a closed loop. Insertion of the adder in the loop results in an accumulator. By temporarily inserting or removing a one-pulse delay in the loop, information can be made to precess, which is equivalent to multiplication by positive or negative powers of two. Input data are supplied to the memory from a keyboard or magnetic tape through the use of a synchronizer which reconciles the randomly timed input signals with the accurately timed internal memory. The same synchronizer is also used for transferring data from the memory to magnetic tape, or to paper by means of an electric typewriter. A.

518.5 : 621.318.572

2352. The design of circuits using electro-mechanical devices. R. A. BROOKER. *J. Sci. Instrum.*, **29**, 45–9 (*Feb.*, 1952).

The two systems on which relay circuits can be designed are described, namely the interlocked and synchronous systems. A general plan for the design of interlocked circuits from two basic units, namely an on-off unit and a bi-stable unit, is described, and examples of circuits using them are given. In the last part of the paper interlocking principles are applied to the design of a communication channel in which a telegraph tape-reader is used as a sender and a modified bi-stable unit—a register unit—as a receiver. These last two items are described in detail. A.

518.61

2353. A new graphical method for the solution of differential equations. A. H. BOERDIJK. *Ingenieur*, **64**, O32–O34 (*Feb.* 15, 1952) *In Dutch.*

Extensions of common vector diagrams, related to a general linear differential equation, are dealt with. With these diagrams it is possible to represent the solution of the differential equation, derivatives of arbitrary order of that solution and also the equality expressed by the differential equation. The diagrams can be applied if the forcing function is a superposition of constants, discontinuities and periodical functions, and also in the case of differential equations with inconstant coefficients, or certain types of non-linear differential equations. The method has been applied to a non-linear electrical circuit. A.

519.2

2354. The probability distribution of the phase of the resultant vector sum of a constant vector plus a Rayleigh distributed vector. K. A. NORTON, E. L. SHULTZ AND H. YARBROUGH. *J. Appl. Phys.*, **23**, 137–41 (*Jan.*, 1952).

Formulae, tables and graphs are given of the cumulative probability distribution of a function frequently occurring in the theory and practice of radiowave propagation as well as in the study of the influence of noise in phase modulation systems. A.

519.2 : 53.088

2355. Logical bases of the design of experiments. Some modern developments in the design of experiments. F. YATES. *Ann. Inst. Poincaré*, **12**, 97–130 (*No.* 2, 1951) *In French.*

A general description of principles, covering confounding, split-plots, fractional replication and

incomplete blocks. The first paper is concerned with fundamental logical and practical questions, and particularly with the availability of a valid estimate of error. The second paper applies the general principles to particular problems. N. L. JOHNSON

519.25

2356. Exact determination of experimental curves showing no trend, using a regularity condition. P. VERNOTTE. *Ann. Franç. Chronom.*, **6**, 211–23 (*No.* 3, 1951) *In French.*

Deals with the problem of fitting the best smooth curve through a set of points with equal ordinates, each being subject to an experimental error with a known upper bound. By differencing, and making trial adjustments to the figures, a polynomial with constant third differences, i.e. a cubic, is fitted to the points. N. CORCORAN

ASTRONOMY . ASTROPHYSICS . GEODESY 52

521.153 : 532.25

2357. Equilibrium of rotating fluids under the quadratic law of stratifications and the existence of equatorial acceleration. N. L. GHOSH. *Proc. Nat. Inst. Sci. India*, **17**, 391–401 (*Sept.–Oct.*, 1951).

Pressure p and angular velocity ω throughout the fluid are calculated for the density distribution $\rho = \rho_0 (1 - \lambda\alpha r^2 - \mu\beta z^2)$, the fluid boundary being $\alpha r^2 + \beta z^2 = 1$. Conditions to be satisfied by the constants λ, μ to ensure surface equatorial acceleration and non-negative values for p, ω^2 and ρ are discussed. Equatorial acceleration will exist for those models whose equidensity surfaces are much flatter than the boundary spheroid. R. A. NEWING

522.23

2358. An eyepiece interferometer. W. S. FINSEN. *Mon. Not. Roy. Astron. Soc.*, **111**, 387–92 (*No.* 4, 1951).

522.6 ; 523.165

2359. A new radio interferometer and its application to the observation of weak radio stars. M. RYLE. *Proc. Roy. Soc. A*, **211**, 351–75 (*March* 6, 1952).

A new type of radio interferometer has been developed which has a number of important advantages over earlier systems. Its use enables the radiation from a weak "point" source such as a radio star to be recorded independently of the radiation of much greater intensity from an extended source. It is therefore possible to use a very much greater recorder sensitivity than with earlier methods. It is, in addition, possible to use pre-amplifiers at the aerials, and the resolving power which may be used is therefore not restricted by attenuation in the aerial cables. Besides improved sensitivity, the new system has a number of other advantages, particularly for the accurate determination of the position of a radio source. Unlike earlier systems the accuracy of position finding is not seriously affected by rapid variations in the intensity of the radiation. It also has important applications to the measurement of the angular diameter and polarization of a weak source of radiation. The new system has been used on wavelengths of 1·4, 3·7, 6·7 and 8 m for the detection and accurate location of radio stars, and for the investigation of the scintillation of radio stars. It has also been used in a number of special experiments on the radiation from the sun. The results which have been obtained in these experiments have confirmed the advantages predicted analytically. A.

522.61 : 523.855

2360. Photographic photometry of extra-galactic nebulae. J.-H. BIGAY. *Ann. Astrophys.*, **14**, 319–82 (*No.* 4, 1951) *In French.*

An application of the Fabry method [see Abstr. 3268 and 5009 (1951)] to determine integrated photographic magnitudes of 175 e.-g. nebulae, with a mean error of $\pm 0{\cdot}1$ m. Absolute mags. for 64 objects have been obtained with frequency max. at $M = -15$, and the linear relation between abs. mag. and rad. vel. is confirmed. The method reveals systematic errors in other methods, viz. *c.* 1·5 m for focal images obtained with short-focus cameras, and *c.* 0·4 m for extra-focal images. Agreement with photcelectric methods, and magnitudes obtained from direct photometric profiles is satisfactory. D. R. BARBER

522.615

2361. An astronomical infrared photometer. Preliminary results. R. HARDIE. *C.R. Acad. Sci.* [*Paris*] **234**, 60–2 (*Jan.* 2, 1952) *In French.*

A photomultiplier cell, with Ag–Cs_2O–Cs cathode (peak response at 8 500 Å) is used in conjunction with either Wratten 87, 88 or Schott UG7 filters to give an eff. sensitivity of *c.* 35 μA/lumen. An example of its use to obtain light-curve of short-period variable star VW Cephei (p = 6 h 41 m) is included. D. R. BARBER

522.617 : 523.75

2362. The solar flare recorder of the Sacramento Peak station of the Harvard College Observatory. J. W. EVANS. *Science*, **114**, 539–44 (*Nov.* 23, 1951).

This description includes a brief discussion of the theory of the interference polarizing monochromator which is the fundamental component.

M. W. OVENDEN

523.11

2363. The evolution of stellar systems. L. E. GUREVICH. *Dokl. Akad. Nauk SSSR*, **79**, 941–4 (*No.* 6, 1951) *In Russian.*

The hypothesis [Abstr. 9250–1 (1951)] of A. I. Lebedinsky, attributing stellar formation to gravitational condensation, leads the author to the view that the accumulations thus produced necessarily proceed to intensive lamination. The various processes involved in this phenomenon are described. Finally, stellar rotation is traced to the establishment of magnetic fields [see also Abstr. 3292 (1949)].

J. CLEUGH

523.11

2364. Expanding world-models characterized by a dimensionless invariant. G. J. WHITROW AND D. G. RANDALL. *Mon. Not. Roy. Astron. Soc.*, **111**, 455–67 (*No.* 5, 1951).

A class of homogeneous expanding world-models, which includes Milne's uniformly expanding model as a particular case, is analysed by the methods of kinematic relativity, red-shifts being attributed in each case to the Doppler effect associated with mutual recession. It is found that each model (of the class) is characterized by the invariance of the dimensionless product $G\rho t^2$, where G is the constant of gravitation, ρ the mean local density and t the parameter occurring in "Hubble's law" (which holds good locally for each model). The "present" ages and (local) densities of several of these models are determined for comparison with the results of observation of the extra-galactic nebulae. A.

523.11 : 530.12

2365. A model universe admitting the interchangeability of stress and mass. G. C. MCVITTIE. *Proc. Roy. Soc. A*, **211**, 295–301 (*Feb.* 21, 1952).

The possibility of the existence of negative stress in the general relativity treatment of a perfect fluid is used to construct a model universe which is in a "gravitationally steady state." Without employing Newtonian analogies, it is shown that stress and mass are mutually convertible into one another in this model, and it is suggested that this process corresponds to the creation of matter postulated in recent cosmological investigations. Using, as the sole empirical datum, the magnitude of the local rate of change of red-shift with distance, plausible assumptions lead to a numerical value of the cosmical constant, to a small value of the density of matter in space and to an unobservably small rate of conversion of stress into mass. The model has an infinitely long contracting phase, followed by an expanding phase which has been proceeding for at least 9×10^9 years. See also Abstr. 5010 (1951). A.

523.161

2366. The chemical composition of the interstellar gas. M. J. SEATON. *Mon. Not. Roy. Astron. Soc.*, **111**, 368–76 (*No.* 4, 1951).

Summaries are given of the atomic ionization and recombination data required in the calculation of interstellar ionization equilibrium. The chemical composition of the interstellar gas is discussed from the standpoint of seeking to establish whether there is any evidence for discrepancies between the interstellar and "mean cosmic" abundance ratios. The important Ca/Na ratio is the only case for which there is an apparent discrepancy, but it is shown that this may be removed if recent work on the ultraviolet radiation field is accepted as correct. A.

523.165

2367. The origin of galactic radio-frequency radiation. J. H. PIDDINGTON. *Mon. Not. Roy. Astron. Soc.*, **111**, 45–63 (*No.* 1, 1951).

The results of observations of the intensity and distribution of radio-frequency radiation from the Galaxy at frequencies from 9·5 to 3 000 Mc/s have been collected. Some of these data are used to determine spectrum curves of the radiation from chosen regions of the Galaxy. Using the equations defining the propagation of radio waves in an ionized gas, the forms of spectrum curves from distributions of gas are determined. It is shown that the power flux of radio energy from a thermally radiating gas cloud increases with frequency except under special conditions which are defined. From a comparison of the observed and the theoretical spectrum curves it is shown that galactic radiation at radio frequencies probably originates partly in hot ionized interstellar gas and partly in stellar atmospheres. The ionized gas provides most of the radiation at the higher frequencies and evidences itself by absorption at the lower. The properties of the stellar sources are discussed. A.

523.4

2368. On the constitutions of the major planets. W. H. RAMSEY. *Mon. Not. Roy. Astron. Soc.*, **111**, 427–47 (*No.* 5, 1951).

The internal constitutions of the major planets are investigated on the basis of the atomic theory of solids. The starting-point of the investigation is the theoretical pressure-density relationship for solid hydrogen at absolute zero temperature; the internal temperatures of the planets are shown to be too low to influence the densities appreciably. It is shown from the empirical mean densities that the most massive planets, Jupiter and Saturn, are predominantly hydrogen. The hydrogen content of Jupiter is about 80% by mass and that of Saturn about 60% by mass. The proportions of hydrogen in these planets are comparable with that in solar material. The internal density distributions in Jupiter and Saturn have been estimated on the assumption of chemical homogeneity. The proportion of heavier elements has been chosen for each planet to agree with its empirical mean density. The computed moments of inertia of the planets are close to, but definitely larger than, the empirical values. This probably means that the heavier elements are not distributed uniformly in the planets but are to some extent centrally condensed. Uranus and Neptune are about ten times as dense as hydrogen planets of the same mass, and their mean atomic weights are about 4; these planets are presumably composed mainly of water, methane and ammonia. The cosmogonical significance of these results is briefly discussed. A.

523.6

2369. On the structure of comets and the formation of tails. R. A. LYTTLETON. *Mon. Not. Roy. Astron. Soc.*, **111**, 268–77 (*No.* 3, 1951).

The self-gravitation of comets is shown to be negligibly small compared with the differential force due to the Sun, and hence the separate particles of comets move practically in independent orbits, except possibly for comets that recede to several hundred astronomical units. A comet cannot be regarded as possessing any permanent shape. The changes in dimensions perpendicular to the general orbital plane are shown to be large. Near perihelion every particle of the comet must cross through this plane. Collisions between a proportion of the particles will occur and reduce them to finer dust, thereby producing particles sufficiently small for the effect of

radiation pressure to create a tail. Changes of dimensions in the orbital plane during a revolution are far smaller. Any slight differences of period must gradually result in particles of the comet being distributed right round the orbit. The possible contribution of the process to the acceleration of Encke's comet is briefly discussed. A.

523.6

2370. Accretion and the origin of comets. P. J. D. GETHING. *Mon. Not. Roy. Astron. Soc.*, **111**, 468–77 (*No.* 5, 1951).

The effect of small density asymmetries in an interstellar dust cloud on the process of accretion by the Sun in its passage through the cloud is considered, with particular reference to Lyttleton's theory of the origin of comets. Such variations in density can give the accreted material a velocity component perpendicular to the axis of accretion sufficient to prevent the material falling into the Sun. Nuclei which might form as a result of the disruption of the accreted material into separate segments can be deflected into periodic orbits, thus apparently removing one of the difficulties of Lyttleton's theory. It appears to be unlikely, however, that the steady state considered by Bondi and Hoyle in earlier papers concerning accretion problems would be reached in the presence of asymmetries. Thus their estimates of the rate at which the Sun can gain in mass might need to be considerably reduced. It is also shown that the influence of random magnetic fields on charged particles will tend to reduce the rate of accretion. A.

523.72

2371. Condition for radiation from a solar plasma. J. FEINSTEIN. Letter in *Phys. Rev.*, **85**, 140 (*Jan.* 1, 1952).

It is shown that the previously accepted use of a point value of a Poynting flux vector within a uniform plasma of infinite extent as a criterion for the reception of h.f. radiation far removed from the oscillating plasma is not permissible. An alternative, unique solution is developed. D. R. BARBER

523.72 : 537.591.5

A solar component of the primary cosmic radiation. *See Abstr.* 2817

523.73

2372. The sun's rotation derived from sunspots 1934–1944 and additional results. H. W. NEWTON AND M. L. NUNN. *Mon. Not. Roy. Astron. Soc.*, **111**, 413–21 (*No.* 4, 1951).

From the combined data of six sunspot cycles there appears no measurable variation in the Sun's rotation period (1) with alternate 11-year cycles, (2) within the (mean) cycle itself. Neither do the two hemispheres, north and south, behave differently. A.

523.75

2373. The motions of eruptive prominences. E. PETTIT. *Publ. Astron. Soc. Pacif.*, **63**, 237–44 (*Oct.*, 1951).

Time-distance and time-velocity plots are reproduced for a number of major prominences; and the results are discussed in relation to errors of observation, and character of the prominence trajectories. D. R. BARBER

523.755

2374. Spectroscopic study of the rotation of the solar corona. B. LYOT AND A. DOLLFUS. *C.R. Acad. Sci.* [*Paris*] **233**, 1529–32 (*Dec.* 19, 1951) *In French.*

By comparing wavelengths of selected coronal lines at E and W limbs of sun with a coronagraph of 4 Å/mm dispersion, the synodic rotation period of the inner corona is found to be 26·8 d, with a p.e. $< 2{\cdot}0$ d, attributed to local motions of the coronal matter $\leqslant 0{\cdot}5$ km/sec (mean vel.). D. R. BARBER

523.77

2375. An attempt to detect a general magnetic field of the sun by a spectrographic method, using a Lummer plate. H. VON KLÜBER. *Mon. Not. Roy. Astron. Soc.*, **111**, 2–17 (*No.* 1, 1951).

The general magnetic field of the Sun has been examined, using a McClean spectrograph crossed with a quartz Lummer plate of excellent quality which gives a resolving power of about 600 000. This was combined with a polarimetric device, consisting of a thick quartz plate and polaroid. Using two carefully selected Fraunhofer lines, one can in this way measure with great accuracy possible small wavelength displacements caused by weak Zeeman effects, the measurements being strictly differential and not affected by possible local Doppler effects. This arrangement was used to obtain spectrograms from two points on the Sun's central meridian at +45° latitude. There were about 60 plates with altogether about 1 000 interference points to be measured. The mean standard error (m.s.e.) for a single determination of the magnetic field strength is about ±6 gauss, and for each set of two corresponding plates about ±3 gauss. For each of the two points on the Sun's meridian 15 pairs of plates have been measured. The internal m.s.e. of all these measurements is ±0·8 gauss for each hemisphere. The final discussion shows that at the time of the observations (1949 August–September) any possible polar field strength was too small to be measured within a m.s.e. of ±0·9 gauss. The scatter of the observations is within the random error of measurement. A field of 1–2 gauss should have made itself evident beyond all doubt on these diagrams. A.

523.774

2376. Identification of CO in the solar atmosphere. L. GOLDBERG, R. R. MCMATH, O. C. MOHLER AND A. K. PIERCE. Letter in *Phys. Rev.*, **85**, 140 (*Jan.* 1, 1952).

Enhanced lines detected in high-dispersion infrared spectra of the solar limb at 23 100–23 300 Å are identified as members of 3–1 vibr.–rotl. band of CO, centred at 4 207·03 cm^{-1}. D. R. BARBER

523.775.5

2377. The sun's corona in different parts of the spectrum. E. V. PYASKOVSKAYA-FESENKOVA. *Dokl. Akad. Nauk SSSR*, **79**, 957–60 (*No.* 6, 1951) *In Russian.*

Results of experiments are discussed in which measurements were made of the illumination on an area perpendicular to rays from the sun and its corona. A corona photometer was used which was fitted with blue, green and red filters corresponding to 445, 546 and 636 mμ. Measurements were made at different times of the year at an altitude of 1 400 metres.

Results obtained on Oct. 10, 1949, for example, indicated that the daily variation of brightness of the corona did not depend on λ for the above wavelengths but only on the value of p, the transparency coeff. The values of p, determined by the slopes of Bugerlines for blue, green and yellow lines were 0·783, 0·843 and 0·881. Results are given graphically and in tabular form. The presence of variable amounts of dust particles and aerosols in the air at different seasons account for different relations between scattering and λ for small scattering angles. W. HUGHES

523.83

2378. Determination of the ellipsoids of stellar velocity residuals from the mean proper motions of 7th. mag. stars. J. DELHAYE. *C.R. Acad. Sci.* [*Paris*] **233,** 1422–4 (*Dec.* 3, 1951) *In French.*

The material used in an earlier research [Abstr. 3289 (1951)] is re-discussed on the basis of the method of Blauw [*Bull. Astron. Inst. Netherlands*, **8** (*No.* 315, 1939)]. Results of the two methods are critically reviewed. D. R. BARBER

523.852

2379. Radio emission from the Andromeda nebula. R. H. BROWN AND C. HAZARD. *Mon. Not. Roy. Astron. Soc.*, **111,** 357–67 (*No.* 4, 1951).

A detailed account is given of the measurement of the radio-frequency radiation from the Great Nebula in Andromeda (M31) using a wavelength of 1·89 m. It is shown that the measured intensity is in good agreement with that to be expected on the assumption that the generation of the radiation is similar to that in the Galaxy. From these results it is estimated that the total extra-galactic radio emission amounts to about 1% of the whole radio flux observed on the Earth. A.

523.852.32

2380. On the motion in barred spirals. R. G. LANGEBARTEL. *Stockholms Obs. Ann.*, **17,** 11 *pp.* (*No.* 3, 1951).

A detailed examination is made of the change in circular orbits due to the building up of a density wave along an axis of a flattened rotating system. The conclusions of an earlier qualitative analysis of Lindblad [Abstr. 4654 (1950)] are confirmed. R. A. NEWING

523.852.32

2381. A polarigraphic study of the spiral nebula NGC 5055 (M 63). A. ELVIUS. *Stockholms Obs. Ann.*, **17,** 17 *pp.* (*No.* 4, 1951).

Appreciable polarization in this galaxy is found in or near a dark lane, the direction being roughly parallel to the isophotes. The dark interstellar matter is evidently concerned in the production of the polarization, and two possible mechanisms are discussed—reflection of light from the nucleus, and absorption of light from behind the dark clouds. A final decision awaits further investigation of the effect in different wavelengths. D. L. EDWARDS

523.855

2382. A model of a spiral galaxy. G. C. MCVITTIE AND C. PAYNE-GAPOSCHKIN. *Mon. Not. Roy. Astron. Soc.*, **111,** 506–22 (*No.* 5, 1951).

It is assumed that the stars which constitute the spiral arms of a galaxy are formed from the disintegration of a bar of material which, at the moment of disintegration, is rotating like a rigid body. After their formation, the stars move under the Newtonian inverse-square-law attraction of a point-mass nucleus located at the centre of the bar. The stars move in elliptical orbits having their perigalactica or apogalactica on the initial position of the bar. The spiral arms are not orbits, but are curves defined by the "present positions" of the stars. The velocities to be expected are also found. The method of solution of the relevant equations is a graphical one. The principal conclusions are: (i) the shape of a galaxy alone does not determine its mass and the age of its arms, but shape, together with velocity of the stars in the arms, does so; (ii) arms may "lead" for parts of their extent and "trail" for the remainder; (iii) a fit can be obtained for the shapes of M51, M81 and M83 and for both shape and velocity of the outer parts of M33; the mass of M33 and the age of its arms are also found; (iv) the shape, mass and age of the Galaxy can be predicted and an explanation obtained of the "leading" arm in the Cygnus direction suggested by radio observations. A.

523.872

2383. Electron temperatures and degrees of excitation in gaseous nebulae. H. ANDRILLAT. *C.R. Acad. Sci.* [*Paris*] **234,** 62–4 (*Jan.* 2, 1952) *In French.*

Intensity ratios, He II (4 686 Å)/$H\beta$ (4 861 Å), or He II/He I (4 471 Å), were measured in spectra of 9 nebulae, and electron temperatures computed [see Abstr. 2350 (1951)]. Values of T_e increased linearly with degree of excitation, and ranged from 9 500°K (N.G.C. 6543) to 25 500°K (N.G.C. 7662). D. R. BARBER

523.875

2384. The luminosity-velocity phase relation of cepheids. P. DUMÉZIL-CURIEN. *C.R. Acad. Sci.* [*Paris*] **233,** 1575–8 (*Dec.* 19, 1951) *In French.*

The obsd. phase effects in cepheid variables may be explained quantitatively in terms of a radially pulsating stellar model, exhibiting discontinuity in the value of γ, the ratio of sp. hts., in the outer zone of its atmosphere. D. R. BARBER

523.877

2385. Non-adiabatic pulsations in stars. D. A. FRANK-KAMENETSKIĬ. *Dokl. Akad. Nauk SSSR*, **80,** 185–8 (*No.* 2, 1951) *In Russian.*

It is argued that the character of pulsation near to the superficies of a star, where adiabatic change cannot be assumed, indicates the entropy oscillations to be in the nature of free waves, displacement oscillations representing the sum of two components conjoined at 90 degrees. Their amplitudes would then vary with the distance from the superficies. J. CLEUGH

523.877

2386. The state diagram of the stars as mass-radius diagram. K. PILOWSKI. *Z. Astrophys.*, **29,** 253–6 (*No.* 3, 1951) *In German.*

Continuation of previous work [see Abstr. 44 (1952)].

523.877

2387. Temperatures and luminosities of *B*-stars. K. PILOWSKI. *Z. Astrophys.*, **30,** 65–70 (*No.* 1, 1951) *In German.*

The criteria of Petrie's method for spectroscopic

double-stars are discussed in relation to the author's interpretation of the mass-luminosity relationship for *B*-type main sequence, and giant stars [see Abstr. 44 (1952)]. D. R. BARBER

523.877

2388. Integration of the Cowling stellar model. J. G. GARDINER. *Mon. Not. Roy. Astron. Soc.*, **111**, 94–101 (*No.* 1, 1951).

A numerical integration of Cowling's stellar model is performed to give a solution of known accuracy. The method is described and the solution tabulated. A.

523.877

2389. Rotational currents. E. J. ÖPIK. *Mon. Not. Roy. Astron. Soc.*, **111**, 278–88 (*No.* 3, 1951).

An analysis of rotational currents is made for the case of small oblateness and constant angular velocity, $\omega = \text{const.}$ Contrary to von Zeipel's paradox, the average energy generation over a level surface of the rotating star is subject to no restrictions; the balancing convective circulation is derived by developing Eddington's method in more detail; a complete system of circulation is calculated for a particular model. As compared with the speed of nuclear reactions, the mixing efficiency of the rotational currents for $\omega = 10^{-4}$ (or 30 times the solar rotation) is almost negligible, being of the same order as gas diffusion and being capable of mixing efficiently not more than the innermost 20% of the stellar mass; for the solar angular velocity the effect is 1 000 times smaller, thus practically nil. Eddington's suggestion that rotational currents are capable of maintaining uniform chemical composition in the radiative equilibrium layers of a star must be definitely rejected except for configurations on the verge of disruption by rotation. A.

523.877

2390. Approximate integration of the equation of transfer. J. B. SYKES. *Mon. Not. Roy. Astron. Soc.*, **111**, 377–86 (*No.* 4, 1951).

The value of numerical integration in obtaining approximate solutions of an equation of transfer, and the different methods available, are discussed. It is shown that although the Newton–Cotes method, used by Kourganoff, is better than the Gauss method, used by Chandrasekhar, both are inferior to a new method, the double-Gauss, discovered by the author. The errors in the approximate values of the source-function and the limb-darkening in all three methods are tabulated for various approximations, and illustrated by graphs. A.

523.877

2391. A model of a red giant star. J. G. GARDINER. *Mon. Not. Roy. Astron. Soc.*, **111**, 102–10 (*No.* 1, 1951).

A model of a red giant star is constructed having a definite composition and the correct boundary conditions. It is shown that a pure hydrogen star having the characteristics of this red giant cannot exist, but that a model having an outer region composed of hydrogen and an inner core of hydrogen and helium is self-consistent. A.

523.877

2392. Models for red giant stars. III. Models with a single discontinuity of composition and opacity due to electron scattering. C. M. BONDI AND H. BONDI. *Mon. Not. Roy. Astron. Soc.*, **111**, 397–409 (*No.* 4, 1951).

For Pt II, see Abstr. 3297 (1951). Models consisting of a hydrogen envelope surrounding a core of higher molecular weight, with opacity throughout the star due to electron scattering, are examined. It is found that considerable (though only finite) extensions of radius can occur with a moderate fraction of the mass of the star in the envelope. The evolutionary tracks in the Hertzsprung–Russell diagram are examined, and good agreement with observation is found. A.

523.877

2393. The calculation of strong absorption lines in stellar spectra. J.-C. PECKER. *Ann. Astrophys.*, **14**, 383–91 (*No.* 4, 1951) *In French.*

From the generalized Minnaert formula for equivalent widths [Abstr. 1297 (1949)] approx. formulae are deduced suitable for rapid computation. Unlike the solar case, for stellar spectra (necessarily with integration over the disk) the Unsöld "weighting function" depends on the intensity of the line.

D. L. EDWARDS

523.877

2394. Stability of two stellar models with variable Γ. R. S. KUSHWAHA. *Proc. Nat. Inst. Sci., India*, **17**, 323–9 (*Sept.–Oct.*, 1951).

The models studied are: (i) a model with central point-mass (1/3 × total mass), with homogeneous density throughout star, and (ii) a Roche-model for which $\Gamma = \Gamma_0(1 - Ar_0^3/R^3)$, where Γ_0 is value of Γ, the effective ratio of sp. hts. for the stellar material, at the stellar centre, A is a constant, r_0, distance from centre of point considered, and R is the stellar radius. It is shown that, for the same law of variation of Γ with r_0, increased conc. of mass will favour stability; and to produce dynamic instability the region for which $\Gamma < 4/3$ must extend to an appreciable fraction of R. Since Γ will also depend on degree of ionization, and presence of elements undergoing ionization, vibrational instability of the star can arise from these internal effects. D. R. BARBER

523.877

2395. The structure and classification of stars of types *R* and *N*. R. BOUIGUE. *C.R. Acad. Sci.* [*Paris*] **233**, 1424–6 (*Dec.* 3, 1951) *In French.*

A proposed classification of *R*- and *N*-type stars is based on two independent criteria: (i) equivalent width of Na *D* lines, and (ii) vibrational temp. of molecular CN (red bands), and C (Swan bands). D. R. BARBER

523.9

2396. Photoelectric recording of stellar occultations. H. E. BUTLER. *Mon. Not. Roy. Astron. Soc.*, **111**, 393–6 (*No.* 4, 1951).

The time of occultation can be compared with broadcast time signals to an accuracy of 1 or 2 hundredths of a second by simultaneous presentation on a cathode-ray tube and photographic recording, using signals derived from the observatory's pendulum clock as a secondary standard.

525.14

2397. On the figure of a planet with homogeneous shell and core. H. JEFFREYS. *Mon. Not. Roy. Astron. Soc.*, **111**, 410–12 (*No.* 4, 1951).

The equations of equilibrium of a two-layer rotating body, with uniform densities in the shell and core, are

solved without use of the Radau approximation. It is found that this approximation loses accuracy appreciably when the central condensation is stronger than in the earth. It remains true, however, that the surface ellipticity and the dynamical ellipticity are much more sensitive to the ratio C/Ma^2 than to the radius of the core. A.

525.35 : 525.6 : 551.556

2398. The effect of winds and tides on the length of the day. Y. MINTZ AND W. MUNK. *Tellus*, **3**, 117–21 (*Aug.*, 1951).

The seasonal variation in the zonal winds of the atmosphere are re-examined and estimated to account for a January to July change of 0·5 msec in the length of the day. Thus only one-third of the change in length of the day reported by astronomers is explained by angular momentum transfers between the earth and atmosphere. The corresponding effect of the varying equilibrium body tide of the earth caused by changes in the sun's distance and longitude is negligible. A.

525.36

2399. Contribution to the theory of Foucault's pendulum. C. PLATRIER. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 762–79 (*No.* 8–9, 1951) *In French.*

Study of the horizontal projection of the trajectory of the pendulum with examples of how it depends on the initial angular velocity about a vertical axis. It is shown why the horizontal component of the earth's angular velocity may be neglected. A. H. COOK

525.722

2400. A diffraction theory of the scintillation of stars on optical and radio wave-lengths. C. G. LITTLE. *Mon. Not. Roy. Astron. Soc.*, **111**, 289–302 (*No.* 3, 1951).

A review of current theories of the scintillation of stars on optical wavelengths shows that the refraction theory of scintillation requires excessive atmospheric density gradients, and fails to explain the observed scintillation in colour, whilst the physiological explanations are insufficient to explain all the observed phenomena. A new theory, in which the scintillation phenomena are attributed to Fresnel diffraction at a non-homogeneous atmospheric layer, is shown to explain the observed effects, and to require considerably smaller density gradients. A similar theory, taking into account the effect of a wavelength change of $\times 10^7$, is shown to explain the observed fluctuations in intensity of radio waves from the localized extra-terrestrial sources of radio noise. A.

PHYSICS 53

FUNDAMENTALS 530.1

530.1

2401. Continuity and possibility. A study of the relation between the subject of mathematics and that of physics. C. F. v. WEIZSÄCKER. *Naturwissenschaften*, **38**, 533–43 (*No.* 23, 1951) *In German.*

530.1

2402. Modern aspects of physics. A. CARRELLI. *Ric. Sci.*, **21**, 2093–2101 (*Dec.*, 1951) *In Italian.*

Brief survey of fundamental particles theory.

530.1 : 513.811

Reflections on a finite approximation to Euclidean geometry. Physical and astronomical prospects. *See Abstr.* 2340

530.12

2403. Studies in the generalized theory of gravitation. II. The velocity of light. O. HITTMAIR AND E. SCHRÖDINGER. *Commun. Dublin. Inst. Adv. Stud. A, No.* 8, 15 *pp.* (1951).

For Pt I, see Abstr. 6019 (1951). The propagation of light is no longer given by $ds^2 = 0$, as it is affected by the skew g_{ik} field which is regarded as the sum of a weak part representing a light wave and a slowly varying background field. The background field produces anisotropy related to results obtained from Born's electrodynamics. For fields of large magnitude, wave fronts cannot proceed in directions within a certain cone of wave-normals. R. A. NEWING

530.12

2404. On the Einstein–Lorentz transformations. Q. MAJORANA. *Atti. Accad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **11**, 241–6 (*Nov.*, 1951) *In Italian.* See Abstr. 751 (1952).

530.12

2405. Physical space and space-time of an observer in relation with other observers. F. AESCHLIMANN. *C.R. Acad. Sci.* [*Paris*] **233**, 1578–80 (*Dec.* 19, 1951) *In French.*

Continuing an investigation of the structure of the space-time of a solitary observer [Abstr. 4685 (1950)], a discussion in general terms is now given of the restrictions imposed if this observer exchanges signals with other observers. R. A. NEWING

530.12

2406. The general static spherically symmetric solution in Einstein's unified field theory. W. B. BONNOR. *Proc. Roy. Soc. A*, **210**, 427–34 (*Jan.* 7, 1952).

The static spherically symmetric solutions of Einstein's unified field equations previously given refer to an electric field alone or to a magnetic field alone. The general solutions in the case where both types of field exist together are now derived. After appropriate boundary conditions have been applied, the solutions may be interpreted to represent a magnetic field arising from a point pole, and an electric field arising from a dispersed charge distribution, but tending asymptotically to that of a point charge. The solutions have an infinity of singular surfaces, contain no arbitrary constant corresponding to the mass of the system, and in them the charge distributions contain both positive and negative electricity at different places. It appears that the only static spherically symmetric solutions likely to have any physical significance are certain of those referring to an electric field alone. A.

530.12

2407. Gravitational deflection of photons with non-vanishing rest mass. A. D. WHEELON. Letter in *Phys. Rev.*, **85**, 383–4 (*Jan.* 15, 1952).

The effect of non-zero mass is found to increase the predicted deflection, the additional term depending on rest-mass and light frequency. In order to account for the Potsdam deflection the added term would be large enough to produce laboratory phenomena which are known not to occur. R. A. NEWING

530.12

2408. Einstein's unified field theory. B. KURŞUNOĞLU. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 81–3 (*Feb.*, 1952).

It is shown that, under certain assumptions about the metric of the space-time, energy momentum tensor of the total field, when Einstein's field equations are satisfied, vanishes identically. A new version of the unified field theory is suggested, and it is indicated briefly that a genuine energy momentum tensor exists which is conserved and has a structure similar to that of general relativity. From the form of the energy momentum tensor and from the field equations of the proposed theory it is concluded that the law of force for a charged mass particle moving in a gravitational and electromagnetic field would have the expected form. A.

530.12

2409. Orbits and rays in the gravitational field of a finite sphere according to the theory of A. N. Whitehead. J. L. SYNGE. *Proc. Roy. Soc. A*, **211**, 303–19 (*No.* 1106, 1952).

The relativity theory of A. N. Whitehead permits one to calculate directly the gravitational field of a set of particles of assigned masses and arbitrary motions, and to investigate the orbits of test-particles and the paths of light rays in such a field. In this paper the hypothesis of Whitehead is extended to cover the case of a continuous distribution of matter; the field of a fixed sphere with a spherically symmetric distribution of matter is calculated and orbits and light rays discussed. Explicit formulae are obtained for advance of perihelion, angular velocity in a circular orbit, and deflection of a light ray. The results differ only slightly from those of Einstein's general theory of relativity by terms involving the distribution of matter in the sphere, except in the case of the deflection of light, for which precisely the Einstein formula (depending only on total mass) is obtained. A.

530.145 : 537.534.74 : 539.185

The analysis of high energy neutron-proton and proton-proton scattering data. *See Abstr.* 3014

530.145

2410. The classical model of the quantum theory. K. F. NOVOBATSKY. *Ann. Phys.* [*Lpz.*] **9**, 406–12 (*No.* 8, 1951) *In German.*

A derivation of the Schrödinger equation, proceeding in the framework of mechanics alone, without use of the optical analogies. According to this treatment, quantum mechanics differs from classical mechanics only in the introduction of an "anticlassic" operator statistics.

530.145

2411. On the problem of the transformation of variables in the theory of distribution. S. ALBERTONI AND M. GUGIANI. *Nuovo Cim.*, **8**, 874–88 (*Nov.*, 1951) *In Italian.*

The principal aim of this work consists in the study of the variables transformation problem in the frame of Schwartz's distribution theory. In particular several formulae concerning Dirac's "singular" functions, frequently used in quantum theory, are proved. A.

530.145

2412. Threshold behaviour in quantum field theory. R. J. EDEN. *Proc. Roy. Soc. A*, **210**, 388–404 (*Jan.* 7, 1952).

The elements of the *S*-matrix are functions of the energies and momenta of a set of incident particles. For sufficiently high relative energies of the incident particles new particles of non-zero rest mass can be created. At the thresholds for such creation processes the *S*-matrix will have a complicated behaviour. This behaviour is investigated when the *S*-matrix is calculated by means of renormalized quantum field theory. For a typical matrix element there are thresholds of two main types. The first is a creation threshold below which the element is zero on account of energy-momentum conservation; mathematically this is due to a Dirac δ function factor. The second is an interference threshold above which a competing process has non-zero probability. Interference thresholds are closely connected with the appearance of displaced poles in the integration. It is shown that a matrix element will always contain a term having a branch point at an interference threshold; the path of analytic continuation round these branch points is obtained from the physical assumption that particles interact through their retarded fields. Between the threshold values it is shown that the *S*-matrix elements are analytic functions of the energies and momenta of the incident particles. A.

530.145

2413. A suggested interpretation of the quantum theory in terms of "hidden" variables. I. D. BOHM. *Phys. Rev.*, **85**, 166–79 (*Jan.* 15, 1952).

The usual interpretation of the quantum theory is self-consistent, but it involves an assumption that cannot be tested experimentally, viz. that the most complete possible specification of an individual system is in terms of a wave function that determines only probable results of actual measurement processes. The only way of investigating the truth of this assumption is by trying to find some other interpretation of the quantum theory in terms of at present "hidden" variables, which in principle determine the precise behaviour of an individual system, but which are in practice averaged over in measurements of the types that can now be carried out. It is shown that as long as the mathematical theory retains its present general form, this suggested interpretation leads to precisely the same results for all physical processes as does the usual interpretation. Nevertheless, the suggested interpretation provides a broader conceptual framework than the usual interpretation, because it makes possible a precise and continuous

description of all processes, even at the quantum level. This broader conceptual framework allows more general mathematical formulations of the theory than those allowed by the usual interpretation. Now, the usual mathematical formulation seems to lead to insoluble difficulties when it is extrapolated into the domain of distances of the order of 10^{-13} cm or less. It is therefore entirely possible that the interpretation suggested here may be needed for the resolution of these difficulties. In any case, the mere possibility of such an interpretation proves that it is not necessary to give up a precise, rational and objective description of individual systems at a quantum level of accuracy.

A.

530.145

2414. A suggested interpretation of the quantum theory in terms of "hidden" variables. II. D. Bohm. *Phys. Rev.*, **85**, 180–93 (*Jan.* 15, 1952).

The interpretation is applied to the theory of measurements. In principle, the "hidden" variables determine the precise results of each individual measurement process. In practice, however, in measurements that we now know how to carry out, the observing apparatus disturbs the observed system in an unpredictable and uncontrollable way, so that the uncertainty principle is obtained as a practical limitation on the possible precision of measurements. This limitation is not, however, inherent in the conceptual structure of the interpretation. For example, simultaneous measurements of position and momentum having unlimited precision would in principle be possible if, as suggested in Pt I, the mathematical formulation of the quantum theory needs to be modified at very short distances in certain ways that are consistent with this interpretation but not with the usual interpretation. A simple explanation is given of the origin of quantum-mechanical correlations of distant objects in the hypothetical experiment of Einstein, Podolsky and Rosen, which was suggested by these authors as a criticism of the usual interpretation. Finally, it is shown that von Neumann's proof that quantum theory is not consistent with hidden variables does not apply to this interpretation, because the hidden variables contemplated here depend both on the state of the measuring apparatus and the observed system and therefore go beyond certain of von Neumann's assumptions. In two appendixes, the problem of the electromagnetic field is treated and certain additional objections are answered.

A.

530.145

2415. On the relativistic invariance of the fundamental canonical equation. P. Wilker. *Helv. Phys. Acta*, **24**, 319–21 (*No.* 4, 1951) *In German.*

Using a homogeneous canonical formalism, in which t also is a generalized co-ordinate, the equation $dr/dt = \partial r/\partial t + [r, H]$ is shown to be Lorentz-invariant only if H is the free particle Hamiltonian, whereas a related set of equations in homogeneous co-ordinates is at once invariant.

R. H. DALITZ

530.145

2416. On the problem of the relations between the unitary transformations of quantum mechanics and the canonical transformations of classical mechanics. L. Van Hove. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 610–20 (*No.* 7, 1951) *In French.*

For classical mechanics is defined the group Γ (directly related to the group of canonical transformations) which corresponds best to the group U of unitary transformations of quantum mechanics. These groups are compared, and it is shown how the absence of isomorphism between Γ and U explains ambiguities inevitably appearing in every procedure for quantizing a system from classical mechanics.

R. H. DALITZ

530.145

2417. A relativistic modification of Bose and Fermi statistics. A. E. Scheidegger and C. D. McKay. Letter in *Phys. Rev.*, **85**, 376–7 (*Jan.* 15, 1952).

The authors' previous results [Abstr. 6732 (1951)] on quantum statistics of fields are modified so that the thermodynamics of a relativistic field reduces to the known non-relativistic limit as $c \to 0$. This modification is further justified by a discussion of the role of constants of the motion in statistical thermodynamics.

R. H. DALITZ

530.145

2418. The normalization group in quantum theory. E. C. G. Stueckelberg and A. Petermann. *Helv. Phys. Acta*, **24**, 317–19 (*No.* 4, 1951).

A brief report of generalizations of Dyson's S-matrix methods, showing that a given set of local interactions can generally be introduced only when further interactions are also added, involving derivatives of $\delta(x)$ to infinite order and actions between any number of quanta. The few exceptions to this result have been discussed previously [Abstr. 6024 (1951)].

R. H. DALITZ

530.145

2419. On the generalized Coulomb scattering of spin-$\hbar/2$ particles bearing a charge and an intrinsic electromagnetic moment. G. Petiau. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 621–9 (*No.* 7, 1951) *In French.*

The differential cross-section for mutual scattering of two spin-$\frac{1}{2}$ particles by exchange of one photon, each particle being coupled to the e.m. field through a charge and an intrinsic moment, is calculated in Born approximation and expressed covariantly.

R. H. DALITZ

530.145

2420. On the universal Fermi-type interaction. II. E. R. Caianiello. *Nuovo Cim.*, **8**, 749–67 (*Oct.*, 1951).

For Pt I, see Abstr. 8513 (1951). A universal interaction is sought among all known fermions based on invariance under the extended Lorentz group which will exclude all processes not occurring in nature. Two mutually exclusive interactions appear ultimately to be the only ones consistent with certain plausible criteria of simplicity. The two possible interactions are proved to yield identical numerical answers in the case of free fermions; one at least of them is in excellent agreement with all the experimental evidence available thus far.

A.

530.145

2421. Problems connected with the prohibition of self-interactions in integro-causal quantum field-theory. F. J. BELINFANTE. *Phys. Rev.*, **85**, 468–73 (*Feb.* 1, 1952).

The electrostatic self-energy of an electron is a quantity based on a wrong formulation of electrodynamics for elementary particles. Omission of the electrostatic self-energy from the formalism of quantum electrodynamics destroys the covariance of the theory, unless one postulates at the same time the absence of self-interaction of electrons through the photon field. This makes the theory integro-causal. Also self-interactions interrupted by other interactions are to be prohibited, if the covariance is to be maintained. The Lamb shift and similar effects then require the introduction of additional interaction terms. Conservation of probability shows that the exclusion of all self-interactions would also cancel the transition probabilities for real physical phenomena. In order to avoid this, the prohibition of self-interactions is to be restricted to those with virtual intermediate states, in which the unperturbed energy is too much different from the energy of the initial (not of the just preceding) state. The problem of expressing this restriction in a covariant form has not yet been solved. A.

530.145

2422. Charge-symmetrical interaction between nucleons and leptons. V. VOTRUBA. Letter in *Phys. Rev.*, **85**, 141–2 (*Jan.* 1, 1952).

It is shown that a Hamiltonian for direct interaction between nucleons and leptons may be written in the form $g_2(\Psi^x r \Psi) \cdot (\phi^x \zeta \phi)$, $\phi = (R\psi_t, \zeta\psi_t, \psi_\tau)$, where τ is the nuclear isotopic spin operator and the components of ξ satisfy the Duffin–Kemmer relations. This is a "lepton isotopic spin." J. R. MADDOX

530.145

2423. Bipolar expansion of Coulombic potentials. Addenda. R. J. BUEHLER AND J. O. HIRSCHFELDER. Letter in *Phys. Rev.*, **85**, 149 (*Jan.* 1, 1952).

A general formula is given for the function $B^{|m|}_{n_1 n_2}(r_1, r_2; R)$ tabulated for some particular values in an earlier work [Abstr. 7530 (1951)] for the case $|r_1 - r_2| \leqslant R \leqslant r_1 + r_2$. R. H. DALITZ

530.145

2424. Renormalization of scalar electrodynamics using β-formalism. A. SALAM. *Proc. Roy. Soc. A*, **211**, 276–84 (*Feb.* 21, 1952).

This paper indicates, in terms of the β-formalism, the general procedure for renormalizing the S-matrix in the theory of charged spin-zero particles interacting with the electromagnetic field. Special identities holding only for the 5-rowed representation of β-matrices are employed to show (i) that the number of primitive divergent integrals is finite, and (ii) that it is possible to arrange an identical cancellation of all but two types of divergences. These last are removed by renormalizations. The mechanism of the proof shows what would be needed if vector electrodynamics is ever to have its divergences absorbed by renormalization techniques. A.

530.145

2425. Remark on the proper Lorentz transformation of the Dirac equations. M. BRDIČKA. *Rozpravy II. Třídy České Akad.*, **60**, 7 *pp.* (*No.* 12, 1950) *In Czech.*

A general proof is given of the Lorentz invariance of Dirac's equations for a single electron in the absence of any external electromagnetic field.

MATHEMATICAL REVIEWS

530.145

2426. The equation of motion of the Landé electron. P. MOLMUD. Letter in *Phys. Rev.*, **85**, 139–40 (*Jan.* 1, 1952).

An equation, which reduces to those of Dirac, Eliezer and Groenewold under different sets of restrictions, is reported. J. R. MADDOX

530.145

2427. Topics in scattering theory. G. BREIT. *Rev. Mod. Phys.* **23**, 238–52 (*July*, 1951).

The connection between relations for changes in energy with relations for changes in phase shift is illustrated, and the relation of the variational treatment to the older methods discussed. The expansion of the f function of Breit, Condon and Present [*Phys. Rev.*, **50**, 825 (1936)] is considered in powers of the energy and parameters entering the assumed expressions for the potential energy, and generalization to $L > 0$ is made. It is found that the above expansion can be made about any energy (not necessarily $E = 0$) and the range of applicability can therefore be extended. The usefulness of f in obtaining fits to experimental data is discussed. W. J. SWIATECKI

530.145

2428. Hamilton's principle and the conservation theorems of mathematical physics. E. L. HILL. *Rev. Mod. Phys.* **23**, 253–60 (*July*, 1951).

For a physical theory derivable from a variational principle, a self-contained account is given of the derivation of conservation theorems from the study of infinitesimal symmetry transformations of the Lagrangian, and the derivation of the equations of motion. To illustrate, the conservation theorems are obtained for n-body classical mechanics and for a scalar meson field theory. R. H. DALITZ

530.145

2429. Representation of nucleon-nucleon singlet S scattering. G. BREIT AND M. C. YOVITS. *Proc. Nat. Acad. Sci.* [*Wash.*] **37**, 771–4 (*Nov.*, 1951).

A study of S-wave p–p scattering theory in which the interrelations between the variational and direct treatments may be simply seen. In the expansion of Breit's f-function in powers of energy or any other linear parameter, the general term may be obtained most easily by combining both approaches.

R. H. DALITZ

530.145

2430. The force between particles in a nonlinear field theory. N. ROSEN AND H. B. ROSENSTOCK. *Phys. Rev.*, **85**, 257–9 (*Jan.* 15, 1952).

It is shown for a general class of scalar non-linear

classical field theories, in which singularities are excluded and particles are represented by small regions in which the field is intense, that the interaction between two particles is described by the Yukawa potential at large distances. A.

530.145

2431. The two-body scattering problem with non-central forces. I. Non-relativistic. G. J. KYNCH. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 83–94 (*Feb.*, 1952).

A perturbation theory is developed for the two-body problem so that central and non-central forces can be treated in a consistent manner. A phase matrix $S(r)$ is introduced which satisfies a first-order Riccati equation. The asymptotic value of S occurs in the formula for the cross-section, and for a special choice of functions is the Heisenberg matrix of the problem. The formalism leads to a simple comparison of neutron-proton and proton-proton scattering, an analysis of the degree of separation of the simultaneous equations which occur, and of the most suitable choice of $S(r)$ for calculation. A.

530.145

2432. The two-body scattering problem with non-central forces. II. Relativistic. G. J. KYNCH. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 94–101 (*Feb.*, 1952).

It has been shown that both for one particle scattered by a centre of force and in the two-body problem, treated relativistically, equations for the S matrix of the Riccati type can be found exactly similar to and as simple in form as those of the non-relativistic approximation. The analytic continuation of this matrix, to determine bound states, has the same limitations as in the non-relativistic problem. A.

530.145

2433. Mathematical aspects of the quantum theory of fields. I–II. K. O. FRIEDRICHS. *Commun. Pure Appl. Math.*, **4**, 161–224 (*Aug.*, 1951).

A presentation of the fundamentals of quantum field theory in a consistent mathematical language. In Pt I the new mathematical considerations implied in the simultaneous spectral representation of an infinite set of commuting operators are discussed and, guided by the methods of Schwartz (Theorie des Distributions, Hermann, Paris, 1950); proper operators satisfying the field theory relations are shown to exist in many cases, despite the δ-functions in these relations. However, no meaning can be given to the usual Hamiltonians, and the valid Hamiltonian of Landau and Peierls [*Z. Phys.*, **62**, 188–200 (*No.* 3–4, 1930)] is discussed in detail. In Pt II, a direct approach to second quantization is given, without the common detour via "box" quantization. An n-variable Hermite polynomial is introduced to discuss the possibility of a representation of field states by functionals, yielding also a simultaneous representation of the field operators, and a definition of integration over Hilbert space is incidentally introduced. R. H. DALITZ

530.145

2434. On the general theory of damping in quantum mechanics. M. SCHÖNBERG. *Nuovo Cim.*, **8**, 817–42 (*Nov.*, 1951).

A general form of the equation of Heitler and Peng, valid for time dependent interactions, is given. The relations between the generalized Heitler–Peng and Schwinger theories of damping are examined in detail. A form of the damping theory given previously by the author is generalized to the case of any time independent interaction. It is shown that the generalized form of the Heitler–Peng treatment of the damping may be used to develop a form of stationary perturbation theory applicable to cases in which it is not possible to set up a correspondence between unperturbed and perturbed stationary states. A.

530.162

2435. Mean first-passage times of Brownian motion and related problems. G. KLEIN. *Proc. Roy. Soc. A*, **211**, 431–43 (*March* 6, 1952).

The theory of first-passage times of Brownian motion is developed in general, and it is shown that for certain special boundaries—the only ones of any importance—mean first-passage times can be derived very simply, avoiding the usual method involving series. Moreover, these formulae have a close analytical relationship to the better-known type of formulae for average "displacements" in given intervals; there exist certain pairs of reciprocal relations. Some new formulae, of mathematical interest, for translational Brownian motion are given. The main application of the general theory, however, lies in the derivation of experimentally particularly useful formulae for rotational Brownian motion. Special cases when external forces are present, and mean reciprocal first-passage times are discussed briefly, and finally it is shown how finite times of observation modify the mean first-passage time formulae of free Brownian motion. A.

530.162

2436. The configurational distribution function in quantum-statistical mechanics. M. L. GOLDBERGER AND E. N. ADAMS, II. *J. Chem. Phys.*, 240–8 (*Feb.*, 1952).

The function $F\{N\}$ which gives the relative probability of a configuration $\{N\}$ is studied for the case of a quantum-mechanical system to which classical statistics can be applied. By means of a device originally used in quantum electrodynamics $F\{N\}$ is obtained in a new form which is very closely related to the form of the analogous classical distribution $F_{CL}\{N\}$. The new form of $F\{N\}$ shows clearly how the difference between $F\{N\}$ and $F_{CL}\{N\}$ is related to the uncertainty principle. As an illustration of the utility of the methods presented here several applications are presented. The first application is a high temperature development of $F\{N\}$ as a power series in $\hbar/kT$ which is carried through to the fourth order. The second application is the development of $F\{N\}$ as a series of configuration space integrals. A previously published low temperature development of $F\{N\}$ is obtained in a simple manner, and it is shown that all higher terms in the development can be written down explicitly by starting from the new form of $F\{N\}$. Finally, several integral equations for $F\{N\}$ are presented which give physical insight into its structure, by establishing mathematical analogies with such physical processes as neutron diffusion. A.

GENERAL MECHANICS . MECHANICS OF SOLIDS 531

531.32

2437. On the motion of a point mass in a resisting medium of variable density. T. Sexl. *Acta Phys. Austriaca*, **5**, 148–51 (*No.* 1, 1951) *In German.*

A point mass is considered falling under gravity with a resistance proportional to the density and to the nth power of the velocity. The solution of the differential equation relating height of fall and time is obtained in a closed form when the density varies exponentially with height in each of the cases $n = 1$ and $n = 2$. J. G. OLDROYD

531.39

2438. Multiple mode operation of servomechanisms. D. McDonald. *Rev. Sci. Instrum.*, **23**, 22–30 (*Jan.*, 1952).

The dynamic operation of servomechanisms should be represented by several equations of motion rather than by a single equation of motion as is commonly done. Usually, the additional modes of operation described by the additional equations of motion represent operation of the servomechanisms under torque or velocity saturation where the performance of the servomechanism is limited. If a servomechanism has these multiple modes of operation, its overall performance can be improved by designing the controller to take maximum advantage of the characteristics of the system for each of its modes of operation. Such a design will result in improved performance with a possible reduction in overall weight. A.

531.555

2439. Phenomena associated with the flight of ultra-speed pellets. I. Ballistics. W. A. Allen, J. S. Rinehart and W. C. White. *J. Appl. Phys.*, **23**, 132–7 (*Jan.*, 1952).

Small metallic pellets have been fired at velocities up to 6 km/sec by means of modified shaped charges. Previous work in this field has been confined largely to observations of meteors and conventional shaped charges. Data obtained on ballistic phenomena verify the conventional drag force determinations extrapolated to large Mach numbers. Steel pellets at velocities of 2·5 km/sec lose little mass in flight. Pellets composed of lighter metals, such as aluminium at a velocity of 5 km/sec, burn vigorously with the emission of much light and heat. It has been found that the motion of both non-burning and burning pellets can be represented within experimental error by the empirical equation $v = v_0 e^{-\alpha s}$, where v_0 is the initial velocity of the pellet, v is its velocity after it has travelled a distance s through the air, and α is a constant. A.

531.66 : 532.58

2440. The force of impact on a cone striking a water surface (vertical entry). M. Shiffman and D. C. Spencer. *Commun. Pure Appl. Math.*, **4**, 379–417 (*Nov.*, 1951).

A cone is considered entering the plane surface of a perfect incompressible fluid normally at constant speed. An "exact" calculation of the force on the cone, involving the numerical solution of an integral equation, is presented in the case of a 120° cone. The known velocity potential corresponding to flow past an ellipsoid circumscribed to the cone is used as the basis of a less laborious approximate method of calculation for a cone of any angle. There is agreement with available experimental results. J. G. OLDROYD

MECHANICAL MEASUREMENTS 531.7

531.715.1 : 535.417

2441. An interference micrometer for diameter measurement of textile filaments in moisture-controlled atmospheres. P. Denton. *J. Sci. Instrum.*, **29**, 55–7 (*Feb.*, 1952).

An instrument is described for determining minute dimensional changes on a specimen enclosed in atmospheres of different but pre-determined moisture condition. Localized Fizeau fringes, formed by reflection from a pair of aluminized glass plates that correspond to the fixed and movable jaws of a normal micrometer, are used as sensitive fiducial indicators for the appropriate setting of a micrometer head. One edge of the movable plate is laid in contact with the specimen and the other rests on a lever, the longer arm of which lies in contact with the micrometer head. This is adjusted until the fringe formation, which is viewed through the eyepiece of a Fizeau interferometer, indicates parallelism of the aluminized surfaces in a direction set by the line joining the ends of the lever; specimen thickness is then derived from the reading on the micrometer and a knowledge of the lever reduction ratio. Air of standard moisture condition moves past the specimen in a glass cell which is fitted with a flat roof to transmit the light beam from the interferometer. The instrument applies a small known force on the specimen and is especially applicable to measurements on compressible bodies. Data on the variation in diameter of cellulose monofilament with moisture condition are presented to illustrate the performance of the instrument. A.

531.715.2 : 536.413

2442. An apparatus for the measurement of small differential expansions and its use for the study of fused silica. R. W. Douglas and J. O. Isard. *J. Sci. Instrum.*, **29**, 13–15 (*Jan.*, 1952).

The differential expansion is magnified by an optical lever, the sensitivity of which is increased by an arrangement of two graticules, the image of one acting as a vernier to the other. Changes of length of 10^{-5} cm can be determined. The apparatus has been used to measure differences in the thermal expansion of samples of fused silica which had been given different heat-treatments. A.

531.717.3 : 620.172.222 : 621.317.733

2443. A bridge circuit for wire resistance strain gauges. B. V. Hamon. *J. Sci. Instrum.*, **29**, 53–4 (*Feb.*, 1952).

Design details are given for a bridge circuit using Waidner–Wolff adjustable resistance elements in the measuring arm instead of the more usual slidewire.

The circuit provides for the measurement of resistance changes from 0·1 to 1% of the gauge resistance to an accuracy of ±0·1%. Provision is made for initial adjustment for a ±2% difference between active and dummy gauges without altering the bridge reading for a given strain. Stability of zero and the effects of contact resistance variations are dealt with. A.

531.752

2444. An automatically recording magnetic balance. J. D. Eisler, G. R. Newton and W. A. Adcock. *Rev. Sci. Instrum.*, **23**, 17–21 (*Jan.*, 1952).

An automatically recording magnetic balance is described which uses an electromagnetic feedback to balance the force on a sample placed in a non-uniform magnetic field. This apparatus has been used for the quantitative determination of the ferromagnetic phases present in iron hydrocarbon synthesis catalysts and for studying the reactions of gases with iron compounds. Typical data are presented. A.

531.785 : 621.838.3

2445. A magnetic fluid dynamometer. D. W. Brede. *Elect. Engng* [*N.Y.*] **71**, 50 (*Jan.*, 1952) [Digest of *Amer. Inst. Elect. Engrs Paper* **51–307** to be published in *Trans* **70** (1951)].

Proceeding from earlier magnetic fluid clutches, the author designed and tested a 10 h.p. magnetic fluid absorption dynamometer weighing 70 lb. Several magnetic fluids were tried, mainly a 7/1 carbonyl E/silicone oil mixture. An arrangement of neoprene O-rings combined with iron guard-rings, which provides a satisfactory seal for the magnetic fluid, is described. Mechanical and electrical characteristics of the dynamometer are given, and it is concluded that a magnetic fluid dynamometer is feasible and can be a useful engineering tool.

G. WITTENBERG

531.787

2446. A modified Budenberg pressure balance. J. F. Pearse. *J. Sci. Instrum.*, **29**, 18–19 (*Jan.*, 1952).

A modification is described which increases the sensitivity and accuracy. A.

MECHANICS OF FLUIDS 532

532.123

2447. A mechanical oscillograph for the analysis of the elastic properties of high polymer solutions. E. H. Frei and A. Stricowsky. Letter in *Bull. Res. Coun. Israel*, **1**, 124–6 (*March*, 1951).

The outer of two concentric cylinders which contain the liquid is oscillated. The horizontal movement of a light beam reflected from the inner is converted by a prism into a vertical movement and is again reflected from the outer, superposing the two oscillations at right angles. The motion is recorded on a phosphorescent screen from which the amplitudes and phase are found. J. E. CAFFYN

532.123

2448. The effect of dissolved gases on the tensile strength of liquids. C. G. Kuper and D. H. Trevena. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 46–54 (*Jan.*, 1952).

A theoretical investigation is made of the amount by which a dissolved gas should reduce the tensile strength of a liquid. The tensile strength is assumed proportional to the surface energy of a vapour nucleus, which is further assumed to have the form of a product of a function of its radius and a function of the dissolved gas concentration. The surface tension of a one-component system is expressed in terms of the van der Waals constants (developing Fowler's theory) and the treatment is extended to a two-component system on the basis of Wall and Stent's theory of van der Waals' binary mixtures. The conclusion is reached that the reduction in the tensile strength of water caused by saturating it with air at a pressure of one atmosphere is less than $\frac{1}{2}$%. A.

532.13

2449. The frictional coefficient for flexible chain molecules in dilute solution. L. Mandelkern and P. J. Flory. *J. Chem. Phys.*, **20**, 212–14 (*Feb.*, 1952).

The frictional coefficient, f_0, of a polymer molecule in dilute solution is assumed to vary directly as an average linear dimension of the chain. From this assumption equations are developed, as follows, which are analogous to those used successfully in the interpretation of intrinsic viscosity measurements; $f_0/\eta_0 = K_f M^{\frac{1}{2}}\alpha$ and $K_f = P(\langle r_0^2\rangle/M)^{\frac{1}{2}}$ where α represents the factor by which the actual root-mean-square end-to-end distance exceeds the unperturbed distance $(\langle r_0^2\rangle)^{\frac{1}{2}}$, M is the molecular weight, η_0 the viscosity of the medium and P should be a universal constant. Data in the literature on the dependence on molecular weight of sedimentation constants and diffusion coefficients, extrapolated to infinite dilution, confirm the conclusions drawn from these equations. A.

532.133

2450. The temperature dependence of viscosity for water and mercury. P. M. Kampmeyer. *J. Appl. Phys.*, **23**, 99–102 (*Jan.*, 1952).

Smoothed values for the viscosities of water and mercury, as reported in the literature, show surprisingly large percentage deviations from the experimental data. Because water is frequently used as the calibrating fluid in viscometry, it was of interest to apply expressions, suggested by the theory of Eyring, for smoothing experimental data. It was of further interest to apply the Arrhenius expression for the variation of viscosity with temperature to the data for both water and mercury and to compare the closeness of fit with that obtained by the use of the aforementioned expressions. As judged by the Gaussian criterion of fit, an expression suggested by the Eyring theory provides smoothed values for the viscosities of both water and mercury which are believed to be more reliable than those in common use. This is especially true for the viscosity of water, for which relative viscosity data were first smoothed and then pinned to the recent value of 10·019 ± 0·003 millipoises at 20°c as reported by Swindells and Coe. From other empirical equations relating densities and energies of vaporization to temperature, equations are derived for expressing the activation energies for viscous flow as a function of temperature. A.

532.133

2451. The viscosities of liquid lithium, rubidium and caesium. E. N. DA C. ANDRADE AND E. R. DOBBS. *Proc. Roy. Soc. A*, **211**, 12–30 (*Feb.* 7, 1952).

The oscillating sphere method has been applied to find the viscosities from the neighbourhood of the m.pt upwards over a range of temperatures. For Li it was necessary to construct a Ni-lined metal sphere, as liquid Li attacks glass and many metals. This involves certain technical difficulties, which have been overcome. The peculiarities of the three metals made necessary the elaboration of special methods of handling. Measurements for Na and K having been already made, the viscosities of all the alkali metals are now available. The results, as regards both the absolute values of the m.pt viscosities and the variation of viscosity with temperature, accord well with the simple theory put forward by one of the authors some years ago. The values for the characteristic temperature which can on this theory be derived from the m.pt viscosities agree well with the values derived from the specific heats for the first three metals, and are calculated for Rb and Cs, for which values derived from other sources are not available. A.

532.137 : 539.374

2452. A servo-mechanical apparatus for the investigation of the properties of visco-elastic materials. L. J. HASTEWELL AND F. J. U. RITSON. *J. Sci. Instrum.*, **29**, 20–3 (*Jan.*, 1952).

An apparatus is described which is suitable for the investigation of the mechanical properties of gels and sols having relaxation times of upwards of one second. The material under test occupies the space between two concentric cylinders and is subjected to constant stress by means of a servomechanism designed to follow smoothly at slow angular speeds. The apparatus is calibrated using a Newtonian liquid of known viscosity so that the absolute values of the parameters specifying the mechanical model of the visco-elastic material can be obtained from the continuous record of the strain variation under constant stress. The determination of the constants of the spring-dashpot model to represent the properties of an aqueous solution of gum tragacanth is given as an example of the use of the apparatus. A.

532.25 : 521.153

Equilibrium of rotating fluids under the quadratic law of stratification and the existence of equatorial acceleration. *See Abstr.* 2357

532.5

2453. On the impossibility of a Poinsot motion for a homogeneous or heterogeneous viscous fluid. R. BERKER. *Istanbul Tek. Üniv. Bül.*, **3**, 61–6 (*No.* 1, 1950) *In French.*

The Poincaré–Appell theorem, that the only possible rigid-body motions of an isolated mass of perfect fluid are steady rotations about an axis fixed in space through the centre of gravity, is shown to apply also to a viscous fluid whose density is an arbitrary function of position. J. G. OLDROYD

532.51

2454. Slow motion of viscous liquid near a half-Pitot tube. W. R. DEAN. *Proc. Camb. Phil. Soc.*, **48**, 149–67 (*Pt I*, 1952).

The slow motion of viscous liquid close to a fixed boundary wall is discussed mathematically, in connection with experimental studies by G. I. Taylor [*Proc. Roy. Soc. A*, **166**, 476 (1938)], T. E. Stanton and others [*Proc. Roy. Soc. A*, **97**, 413 (1920)] of such motion, by small half-Pitot tubes of rectangular section, one side of the rectangle being formed by the boundary wall, the dimension of the rectangle perpendicular to the wall being much smaller than the small opening of the tube parallel to the wall. The solution is obtained by the method of conformal representation. The stream function, ψ, satisfies the biharmonic equation $[\partial^2/\partial x^2 + \partial^2/\partial y^2]^2\psi = 0$ and the boundary conditions $\psi = \partial\psi/\partial n = 0$ along the normal, while ψ must give a uniform shearing motion apart from the disturbance due to the boundary. In discussing Stanton's paper, Taylor pointed out that the half-Pitot pressure should tend to a finite limit, $p_1 = K\mu\alpha$, where $\mu\alpha$ is the tangential stress, and α is the undisturbed rate of shear at the boundary. By experiment, using glycerine, Taylor found $K = 1{\cdot}2$. It is now shown theoretically that $K = 1{\cdot}67$, but the simplifying assumptions made in the theory may account for the difference between the theoretical and experimental values. Barker [*Proc. Roy. Soc. A*, **101**, 435 (1922)] found $K = 1{\cdot}5$, while Dean made an indirect estimate $K = 1{\cdot}45$. J. S. G. THOMAS

532.51

2455. The slow motion of a sphere along the axis of a rotating fluid. K. STEWARTSON. *Proc. Camb. Phil. Soc.*, **48**, 168–77 (*Pt I*, 1952).

The perturbation of the velocity of an inviscid incompressible fluid, rotating about an axis with uniform angular velocity, Ω, due to the slow uniform motion, after an impulsive start, of a sphere of radius a, along the axis with velocity, V, is discussed mathematically [see Taylor, *Proc. Roy. Soc. A*, **102**, 114 (1922); **104**, 213 (1923)]. An integral form of solution of the problem is obtained by the use of a Laplace transformation, on the assumption that the relative motion is small, power series expansions and asymptotic expressions being derived for the velocity and pressure. In general, the ultimate motion is steady, two-dimensional and small, and a cylinder of fluid of the same radius, a, as the sphere is pushed along in front of the sphere. The fluid inside the cylinder has an increased angular velocity, but the cylinder acts as an impassable barrier to make the flows inside and outside the cylinder apparently independent. Exceptions to the two-dimensional motion occur on the sphere, where the velocities oscillate finitely, on the axis where the axial velocity oscillates finitely, and on the cylinder $r = a$, where the component velocities, v and w, along the co-ordinates θ and z of a system of cylindrical polar co-ordinates (r, θ, z) (z being along the axis of rotation) increase indefinitely with Ωt. J. S. G. THOMAS

532.517

2456. Direct determination of the flow curves of non-Newtonian fluids. I. M. KRIEGER AND S. H. MARON. *J. Appl. Phys.*, **23**, 147–9 (*Jan.*, 1952).

A method is proposed for the direct determination of the rate of shear-shearing stress curve of a fluid from data obtained in concentric cylinder viscometers. The method involves the use of a viscometer

in which the ratio of outer to inner cylinder radii can be varied. It is further shown that to a close approximation two such radius ratios are sufficient to define the flow curve. Data for two non-Newtonian systems are presented to show that the proposed method is valid. A.

532.517.4

2457. Further observations of the turbulent fluctuations in a tidal current. K. F. Bowden and L. A. Fairbairn. *Philos. Trans A*, **244**, 335–56 (*No.* 883, 1952).

The component of turbulent velocity in the direction of the mean flow has been studied for the tidal current in the Mersey estuary. Two Doodson current meters were used, recording simultaneously on the same photographic paper. The more interesting results were obtained within about 2 m of the bottom, the two meters being supported in a stand, with various vertical and horizontal separations. The periods of the turbulent fluctuations recorded varied from a few seconds up to several minutes. Various methods of analysis have failed to show any predominant periods or bands of periods (when the effects of surface waves have been excluded), and it appears that, as in other types of turbulence, a continuous spectrum of fluctuations is present. Distance-correlation coefficients in the vertical and lateral directions have been computed from the simultaneous recordings, as well as auto-correlation curves from the recordings of the individual meters. Inferring the distance-correlation in the direction of flow from the auto-correlations, the integral scale of the turbulence in this direction is estimated to be of the order of 7 m, compared with 14 m, the mean depth of water. From the simultaneous correlations, it is suggested, tentatively, that the scales in the vertical and lateral directions are of the same order of magnitude and of the order of one-third of the scale in the direction of the mean flow. A.

532.517.4

2458. On turbulence caused by thermal instability. S. Chandrasekhar. *Philos. Trans A*, **244**, 357–84 (*No.* 884, 1952).

A statistical theory of turbulence in an incompressible fluid caused by the joint effects of gravity, and thermal instability, is developed. The mathematical theory is based on the equations of continuity and heat conduction and the Boussinesq form of the equations of motion in which the variations of density (resulting from the variations in temperature) are taken into account only in so far as they modify the action of gravity. Restriction to a portion of the fluid far from the bounding surfaces allows the turbulence to be treated as approximately homogeneous and axisymmetric and use the theory of axisymmetric vectors and tensors recently developed by the author [Abstr. 5558 (1950)]. A number of correlations between the various field quantities (such as the velocity components, fluctuations in temperature, etc.) at two different points in the medium are defined; and a closed system of equations for the defining scalars are derived for the case when the non-linear terms in the equations of motion and heat conduction can be neglected and a constant mean adverse temperature gradient is maintained. Under stationary conditions when the time derivatives of the various correlations are zero, there is an exact balance between the dissipation of kinetic energy by viscosity and the liberation of potential energy by gravity. A fundamental set of solutions of the equations governing stationary turbulence is obtained; these solutions, varying periodically in the vertical direction, enable a generalized Fourier analysis of the various correlation functions. According to these solutions, a Fourier analysis of correlations such as $\overline{u_{\|}(0)u_{\|}(z)}$ of the vertical velocities at two points directly above one another and separated by a distance z, cannot include wavelengths less than a certain minimum value depending on the physical parameters and on the temperature gradient maintained. A smallest size for the eddies can thus be spoken of. Further, it appears that the field of turbulence can be analysed into two modes characterized by the kinetic energy being confined, principally, to the vertical or to the horizontal direction. A.

532.52 : 532.62

2459. Water bells. F. L. Hopwood. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 2–5 (*Jan.*, 1952).

The author shows that when water is discharged through an annular slit above a plane water surface, the sealed "water bells" thus formed exhibit some novel and remarkable properties not hitherto described. The primitive water bell is a dome-shaped bubble whose dimensions increase with increased rates of flow. If this is perforated with a finger the maximum diameter of the bell suddenly doubles itself. On continuously reducing the flow the expanded bubble contracts and assumes an alternating sequence of stable and semi-stable forms of great beauty. All these, when perforated, contract slightly. The semi-stable forms have the general appearance of a hyperboloid surmounted by a saucer-shaped depression with the annular slit at the bottom. On inflating an expanded bubble by a slow stream of small air bubbles, semi-stable forms similar to the above are produced, but possessing an additional inflection in their contours. During these changes the maximum differences of pressure do not exceed one-tenth of a millimetre of water above or below atmospheric pressure. The author shows how the apparatus can easily be modified to produce enclosing water bells. It may also be adopted to produce sonic and ultrasonic underwater vibrations. A.

532.528

2460. Cavitation produced by ultrasonics: theoretical conditions for the onset of cavitation. E. A. Neppiras and B. E. Noltingk. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 1032–8 (*Dec.*, 1951).

An attempt is made to define theoretically the conditions for the appearance of cavitation in liquids subjected to alternating pressure changes. It is found that cavitation is restricted to a definite range of variations of the following parameters: (i) alternating pressure amplitude, (ii) frequency of the pressure wave, (iii) radius of the bubble nucleus, (iv) hydrostatic pressure. Under certain conditions, the change from non-cavitating to cavitating conditions is found to be exceedingly sharp, and in these cases it is shown

that the threshold for cavitation can be accurately expressed in very simple terms. A.

532.58

2461. The action of waving cylindrical tails in propelling microscopic organisms. G. TAYLOR. *Proc. Roy. Soc. A*, **211**, 225–39 (*Feb.* 21, 1952).

The tail is assumed to be a flexible cylinder which is distorted by waves of lateral displacement propagated along its length. The resulting stress and motion in the surrounding fluid is analysed mathematically. A working model was made and its performance compared with the calculations. A.

532.59

2462. Some gravity wave problems in the motion of perfect liquids. *Philos. Trans A*, **244**, 231–334 (*No.* 882, 1952).

General Introduction. W. G. PENNEY. (231–5).

I. The diffraction theory of sea waves and the shelter afforded by breakwaters. W. G. PENNEY AND A. T. PRICE. (236–53).

Use is made of the solutions of mathematically analogous problems in the diffraction of light. The wave patterns and wave heights are determined on both the leeward and windward sides of the breakwater, and for points quite close to the breakwater. This involves some extension of the calculations previously made for optical phenomena. The conditions obtaining in the lee of a small island are discussed. The penetration of waves through a single gap in a long breakwater is examined, and the result is shown to depend very much on whether the gap is small or not compared with the length of the waves. The investigation was suggested by problems arising in the construction of the Mulberry harbours. A.

II. Finite periodic stationary gravity waves in a perfect liquid. W. G. PENNEY AND A. T. PRICE. (254–84).

The possible existence, form and maximum height of strictly periodic finite stationary waves on the surface of a perfect liquid are discussed. A method of successive approximation to the solution of the hydrodynamical equations is formulated, and the solution is carried to the fifth order for the case of two-dimensional waves on a deep liquid. The convergence of the method has not been established, so that the existence of truly periodic stationary waves is not beyond doubt, but the calculations provide strong presumptive evidence for their existence, and for the existence of a finite stable wave of greatest height. The crest of this wave has a right-angled nodal form, in contrast with that of the greatest stable travelling wave for which the nodal angle is 120°. The maximum crest height is $0{\cdot}141\lambda$, where λ is the wavelength, and the maximum trough depth is $0{\cdot}078\lambda$. This means that the greatest stationary waves are greater than the maximum travelling waves, the ratio being 1·53. The motions of individual particles are studied and it is shown that particles in the surface, particularly those near the anti-nodes, have large horizontal motions. For a given wavelength, the period increases with wave height. The wave pressure on a breakwater is examined, and the modification of the calculations to allow for the finite depth of water is considered. Doubly modulated oscillations in a deep rectangular tank are also discussed. A.

III. The dispersion, under gravity, of a column of fluid supported on a rigid horizontal plane. W. G. PENNEY AND C. K. THORNHILL. (285–311).

The dispersive motion of a fluid column, collapsing under its own weight whilst immersed in a lighter fluid, both fluids resting on a rigid horizontal bottom, is idealized as a symmetric problem of incompressible potential flow. The velocity potentials in the two fluids are functions of two space-variables and time, and satisfy Laplace's equation in the two space-variables; and the principal boundary conditions are that, at every point of the fluid interface, the two fluid pressures are equal, and the two normal fluid velocities are both equal to the normal velocity of the interface itself. The initial accelerations of the boundary of a column of semicircular cross-section are derived analytically. An approximate numerical method of solution for the early stages of such a motion is obtained by satisfying these boundary conditions at only a finite number of angular positions instead of everywhere on the fluid interface. Some calculations by this method are shown for certain fluid columns *in vacuo*. Alternatively, by neglecting vertical accelerations in the motion, the problem is reduced to one of hyperbolic type in one space-variable and time, and this approximation may be solved by the numerical method of characteristics. Some calculations of this type are also shown, in which vertical accelerations have been neglected *ab initio*, and which are therefore appropriate to initially squat columns. The hydrodynamical problem of the collapse of a fluid column surrounded by a second lighter fluid, both resting on a rigid horizontal plane, was suggested by the "base surge" observed at the Atomic Weapon Trials at Bikini. A.

IV. An experimental study of the collapse of liquid columns on a rigid horizontal plane. J. C. MARTIN AND W. J. MOYCE. (312–24).

An experimental study has been made of some aspects of the phenomena accompanying the collapse of liquid columns on to a rigid horizontal plane with air as the outer medium. The cases covered include the two-dimensional collapse of rectangular and semicircular sections, and the three-dimensional axial collapse of right circular cylinders. As the columns collapsed, the fluid spread across the horizontal plane, attaining a maximum velocity, which, in the two-dimensional cases, was proportional to the square root of the original height. It was not clear whether this proportionality would hold for the axial collapse of cylinders. If it did, then the factor of proportionality would be some 25% lower. In the two-dimensional cases the top of the residual column accelerated downwards to a maximum velocity proportional to the square root of the product of the original height and the original height to base ratio. The nature of the subsequent retardation indicated that the downward velocity probably approached zero asymptotically with time. A.

V. An experimental study of the collapse of fluid columns on a rigid horizontal plane, in a medium of lower, but comparable, density. J. C. MARTIN AND W. J. MOYCE. (325–34).

The results of an investigation of collapse of fluid right-circular cylinders in a medium of comparable

density are described. Qualitative and quantitative similarities between the surges produced by the collapse of such columns and the base surge observed at Bikini are examined, and by the use of simple scaling laws, an estimate of the quantity of finely divided water in the stem of the column of the Bikini plume is obtained. A.

532.593

2463. On the highest gravity waves on deep water. H. JEFFREYS. *Quart. J. Mech. Appl. Math.*, **4**, 385–7 (*Dec.*, 1951).

The method of Michell and Havelock in discussing the form of the highest possible progressive waves is improved by estimating the sum of a slowly convergent series by L. F. Richardson's method of deferred approach to the limit. L. S. GODDARD

532.595

2464. Oscillatory phenomena in hydrodynamics. L. A. SACKMANN. *Ann. Franç. Chronom.*, **6**, 203–9 (*No.* 3, 1951) *In French.*

The pseudo-period of isochronous oscillations of a column of liquid of length l contained in a U-tube is $T = 2\pi\sqrt{(l/2g\cos\alpha)}(1+\varepsilon)$, where α is the angle between the U-tube and the vertical, and ε depends on viscous damping. Scatter of less than 1% from the mean value of $T^2/(l/2)$ is reported for mercury columns of various lengths in a vertical glass U-tube. With an inclined U-tube, deviations from theoretical values were found to increase with inclination, owing to capillary effects, reaching 6% at $\alpha = 87°$.

CAPILLARITY 532.6

532.61.08

2465. Measurement of the phase-boundary tension of liquids. H. UMSTÄTTER. *Arch. tech. Messen, Issue No.* 190 (*Ref. V* 9122–8) T126–T127 (*Nov.*, 1951) *In German.*

An illustrated description of the following methods of measuring the surface tension of liquids: (1) ring method of Lecomte du Noüy, (2) Traube's stalagmometric method, (3) bubble-pressure method, (4) capillary rise method, and (5) dynamic methods (Rayleigh's oscillating jets; interference of waves). The last section deals with the Adam-Jessop trough.

F. LACHMAN

532.62

2466. The collapse and rebound of a gas bubble. L. TRILLING. *J. Appl. Phys.*, **23**, 14–17 (*Jan.*, 1952).

The velocity and pressure field in a slightly compressible liquid resulting from the collapse of a spherical bubble is computed as a function of the pressure at the bubble wall, using the acoustic approximation. The results are accurate as long as the liquid velocities are small compared to the sonic velocity in the liquid; they agree with the results previously obtained by C. Herring. The following bubble model is then investigated. The bubble is supposed filled with inviscid perfect non-conducting gas; special emphasis is given to the gas motion which involves a series of shock waves. A fraction of the energy of compression is thus degraded so that the radius of the bubble after the first rebound is somewhat less than the original radius. The pressure variation at the bubble wall is virtually the same as if the gas were compressed uniformly and isentropically.

A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.7 : 530.162

2467. A new method of solving the Born–Green equation for the radial distribution function. A. G. MCLELLAN. *Proc. Roy. Soc. A*, **210**, 509–17 (*Jan.* 22, 1952).

A solution of the Born–Green equation for the radial distribution function may be found as a series in ascending powers of the density. This method is applied to a fluid of rigid spherical molecules, and the results are compared with those which Kirkwood, Maun and Alder obtained by means of numerical integration. For such molecules it is possible to show that the close-range structure at a distance between n and $n+1$ diameters from a central molecule is of the order of the density raised to the nth power (n integral). When the Lennard–Jones potential function is employed, the first and second approximations to the radial distribution function thus obtained are shown to be identical with those resulting from a rigorous development of this function in powers of the density.

A.

532.7 : 532.122

2468. Classical theory of compressibility. P. J. PRICE. *Proc. Phys Soc.* [*Lond.*] *A*, **65**, 54–6 (*Jan.*, 1952).

By extending Green's treatment of the classical virial theorem, a formula for the bulk modulus of an assembly of atoms, when classical physics applies, is derived. This formula involves the binary and ternary distribution functions. A.

532.7 : 534.22

Ultrasonics and the structure of liquids. *See Abstr.* 2499

532.72

2469. Diffusion through an interface—binary system. L. H. TUNG AND H. G. DRICKAMER. *J. Chem. Phys.*, **20**, 6–9 (*Jan.*, 1952).

Diffusion measurements have been made between saturated layers in the system SO_2–*n*-heptane, using S^{35}-tagged SO_2 as a radioactive tracer. The results are evaluated in terms of the interfacial transfer coefficient α introduced by the authors [to be published]. The resistance in the interface is significant compared with the resistance to ordinary diffusion, even within 4°C of the critical solution temperature.

A.

532.72

2470. Diffusion through an interface—ternary systems. L. H. TUNG AND H. G. DRICKAMER. *J. Chem. Phys.*, **20**, 10–12 (*Jan.*, 1952).

Diffusion measurements have been made at 22°C and at 40°C in the system phenol-H_2SO_4-water, using S^{35}-tagged H_2SO_4 as a radioactive tracer. Measure-

ments made through the interface indicate that a significant resistance resides in the interface at both temperatures, and that the solution chemistry of the system must be quite complex. The relation of the results to practical mass transfer problems is briefly discussed. A.

532.73 : 537.531 : 535.43

2471. Diffraction of X-rays by aqueous solutions of some sulphates. E. TARTAGLIONE. *Nuovo Cim.*, **8**, 977–80 (*Dec.*, 1951) *In Italian.*

The author has studied the diffraction of X-rays presented by water and $CuSO_4$, $FeSO_4$, $MnSO_4$ solutions. It has been shown that, in accordance with other work on the Raman effect, the three salts have a specific action on the solvent; $CuSO_4$ and $FeSO_4$ enhance the processes of the molecular association of water, but $MnSO_4$ produces an opposite effect. A.

532.739

2472. The temperature dependence of the solubility of solid nonelectrolytes. J. H. HILDEBRAND. *J. Chem. Phys.*, **20**, 190–1 (*Jan.*, 1952).

The solubilities of nonelectrolytes in solutions from which chemical interactions are absent, when plotted as logarithm of mole fraction *v.* logarithm of absolute temperature, yield practically straight lines except near the melting-point of the solute. This offers a superior method of smoothing out solubility data and of predicting the temperature coefficient of solubility from a single point by comparison with neighbouring lines for other solvents. An explanation is given for this behaviour. A.

532.74

2473. A tentative explanation of the "Weissenberg effect" in latex solutions. E. H. FREI AND A. KATCHALSKY. Letter in *Bull. Res. Coun. Israel*, **1**, 113–16 (*Aug.*, 1951).

In slightly vulcanized latex solutions sheared between rotating coaxial cylinders, radial pressures are observed to increase to a maximum and then decay to zero in a few seconds; recovery of initial properties on standing takes several hours. An explanation involving the degradation and re-formation of molecular aggregates is put forward. J. G. OLDROYD

532.77 : 534.22

The velocity of sound in electrolytic solutions. *See Abstr.* 2500

532.77 : 536.7

2474. The prediction of thermodynamic properties of nonideal solutions from turbidity measurements. A. L. BABB AND H. G. DRICKAMER. *J. Chem. Phys.*, **20**, 290–3 (*Feb.*, 1952).

Turbidity measurements have been made on the systems CH_3OH–*i*-C_5H_{12}, CH_3OH–*n*-C_5H_{12}, CH_3OH–*n*-C_6H_{14}, near the critical solution temperature at 7 atm. pressure and at a considerably higher pressure. The effect of pressure is to elevate the critical solution temperature and to decrease the minimum transmission. The wavelength dependence is consistent with the theory of Ornstein and Zernike. The change of fugacity with concentration is calculated as a function of temperature, pressure and composition. A.

533.15

2475. The diffusion of metastable neon atoms in mixtures of helium and neon. F. A. GRANT. Letter in *Phys. Rev.*, **84**, 844–5 (*Nov.* 15, 1951).

This is measured using a discharge tube, and from the experimental results the diffusion coefficients of metastable neon atoms in helium and neon deduced. J. HUGHES

533.15 : 532.71

2476. The thermo-osmosis of gases through a membrane. I. Theoretical. K. G. DENBIGH AND G. RAUMANN. *Proc. Roy. Soc. A*, **210**, 377–87 (*Jan.* 7, 1952).

The process of thermo-osmosis is the passage of a fluid through a membrane due to a temperature gradient. Under suitable conditions it gives rise to a stationary difference of pressure. The thermo-osmosis of a gas through a membrane in which it is slightly soluble is due partly to the temperature coefficient of its solubility and partly to the existence of a thermal diffusion process inside the membrane. A theory is developed on the basis of Onsager's treatment of irreversible processes and leads to equations giving the rate of permeation and the pressure ratio at the stationary state. The magnitude of the effect depends on the algebraic sum of the heat of solution and the heat of transport within the membrane. A.

533.15 : 532.71

2477. The thermo-osmosis of gases through a membrane. II. Experimental. K. G. DENBIGH AND G. RAUMANN. *Proc. Roy. Soc. A*, **210**, 518–33 (*Jan.* 22, 1952).

An apparatus is described for the measurement of the thermo-osmotic effect of CO_2, N, H and water vapour through a natural rubber membrane. The existence of the effect is demonstrated in all four cases. The experimental results are in accord with the theoretical expressions of Pt I concerning the rate of penetration through the membrane and the pressure ratio at the stationary state. The calculated values of the heat of transport are discussed with special reference to a molecular-kinetic theory of diffusion in quasi-crystalline lattices. A.

533.15 : 541.135

2478. An experimental investigation of the diffusion of electrolytic hydrogen through metals. H. R. HEATH. *Brit. J. Appl. Phys.*, **3**, 13–18 (*Jan.*, 1952).

Experiments have been made to test whether H produced electrolytically on one side of a metal plate will diffuse through the plate. The Shakespear katharometer was used to detect and measure the diffused gas. The metals examined were Fe, Ni, Co, Cu, Zn, Ag, Pd, Pt and Pb. Only in the case of Fe and Pd was any diffusion observed. Measurements were made with Fe showing how the amount of diffused gas varied with time, and how the rate of steady diffusion varied with the thickness of the plate. The variation of the rate of diffusion with the electrolysing current density was observed for plates of Fe and Pd. The results agree well with those of other observers for large values of the current density, but

show that a threshold value of current density does not exist and that for low values of current density the rate of diffusion is approximately proportional to it. The diffused gas appears to be in the ordinary molecular state. A simple theory which explains the general character of the experimental results is given. A.

533.5 : 621.383 : 621.316.71.076.7

2479. Photoelectric vacuum controller. C. G. Youngs, T. M. Mallard and B. M. Craig. *Canad. J. Techn.*, **29**, 447–50 (*Oct.*, 1951).

The controller consists of a Dubrovin pressure gauge, light source, photocell and electronic relay. When the photocell is energized by light, the relay is closed. With decreasing pressure the float in the Dubrovin gauge rises, interrupting the light beam to the photocell, opening the circuit, thus stopping the vacuum pump or actuating a solenoid valve. Arrangement of components and electronic relay circuit is shown diagrammatically. The controller is satisfactory to $\pm 0{\cdot}1$ mm over the 1 to 20 mm Hg pressure range. G. WITTENBERG (R)

533.6 : 551.578.1

2480. Free fall of drops through air. W. Hitschfeld. *Trans Amer. Geophys. Un.*, **32**, 697–700 (*Oct.*, 1951).

Terminal velocity data of water drops are used for the quantitative description of their accelerated motion when falling freely from rest. The method, based on the principle of aerodynamic similarity, is valid for water drops of radius $1{\cdot}6$ mm or less. Using, as an example, the Schmidt relation for terminal velocity, general expressions are obtained for the time of fall and the distance fallen as functions of the velocity of fall attained. Numerical results calculated for drop radii of $0{\cdot}625$, $1{\cdot}00$ and $1{\cdot}50$ mm agree well with the measurements of Laws. A.

533.6.01

2481. The Mach reflection of shock waves at nearly glancing incidence. C. H. Fletcher, A. H. Taub and W. Bleakney. *Rev. Mod. Phys.*, **23**, 271–86 (*July*, 1951).

The interaction of a plane shock wave in air with a plane rigid wall involves (1) a regular reflection in which the incident shock is followed by a reflected shock which joins the incident shock wave at the wall, and (2) Mach reflection in which the reflected shock wave meets the incident shock at a triple point or line at some distance from the wall and is joined to it by a third shock wave (usually curved) called the Mach shock. The mathematics of the Mach reflection of shock waves at nearly glancing incidence is here developed by linearizing both the differential equation of wave propagation and the boundary condition. The methods employed by Bargmann, Lighthill [Abstr. 6822 (1949)] and by Ting and Ludloff [*J. Roy. Aero. Soc.*, **18**, 143 (1951)] are discussed, and their results compared with experimental results. Preliminary experiments have shown qualitative agreement with Bargmann's results. Experimental evidence indicates that the observed slip streams are density discontinuities, and occur in the reflection of any shock at suitable angles not in the region of near-glancing incidence. For strong incident shocks, there is agreement between the observed shock configuration and that required by the local three-shock theory. The slip stream in the case of weak incident shocks, where the configuration violates the local three-shock theory, appears, experimentally, to be a sharp density discontinuity; a calculation similar to that of Ting and Ludloff, but for weak shocks, would show a broad region of changing density. The fundamental problem of Mach reflection of weak shocks has not yet been solved. J. S. G. THOMAS

533.6.01

2482. Steady-state, one-dimensional flow in rocket motors. E. W. Price. *J. Appl. Phys.*, **23**, 142–6 (*Jan.*, 1952).

Solutions are presented for the problem of gas flow in a solid propellant rocket motor using combined numerical and graphical methods. The character of the problem, sources of information, and method of solution are described, and solutions for the case of JPN ballistite propellant are presented. These solutions give the equilibrium distributions of pressure, density, velocity and temperature of the gas stream and burning rate of the solid propellant as functions of two characteristic parameters β and J. These parameters are descriptive of the charge geometry and flow channel geometry, respectively. The solutions cover the entire range of nozzle, charge-size combinations, including the case of no nozzle. A.

533.6.011

2483. On virtual mass and transient motion in subsonic compressible flow. J. W. Miles. *Quart. J. Mech. Appl. Math.*, **4**, 388–400 (*Dec.*, 1951).

The motion is discussed on the basis of the acoustic approximation. If a velocity is imparted suddenly to a body half the work is lost in radiation. The velocity and acceleration resulting from a constant force suddenly applied to a circular cylinder are calculated. Various other cases are considered. It is concluded that the radiation loss due to acceleration is not likely to be important in practice, with the possible exception of airships and submarines. L. S. GODDARD

533.6.011.3

2484. Conical flow in the neighbourhood of a junction. J. Legras. *C.R. Acad. Sci.* [*Paris*] **234**, 181–3 (*Jan.* 7, 1952) *In French.*

Conical, supersonic, fluid flow at an obstacle, in the form of a plane plate limited by a right angle, arranged so that the border of the attack is perpendicular to the velocity of the flow of fluid at infinity, the obstacle being partly within and partly outside the Mach cone, is discussed mathematically. Plane shock waves, envelopes of shock cones having their apex at the border of attack, and a conical shock wave with its apex at the angle, the two sets of shock waves having a common junction-line, are produced. An expression for the flow, except in the region of the junction line, can be obtained by using the method due to Lighthill, in which the flow potential is expressed in conical variables [Abstr. 2249 (1950)]. Whitham's method of solution of the fundamental flow equation [Abstr. 150 (1951)] is generalized, by the use of a parametric representation, applicable in the neighbourhood of a junction point, to determine the shock wave and the velocity field. J. S. G. THOMAS

MOLECULAR THEORY OF GASES 533.7

533.7

2485. The second virial coefficients of mixed organic vapours. J. H. P. Fox and J. D. Lambert. *Proc. Roy. Soc. A*, **210**, 557–64 (*Jan.* 22, 1952).

The second virial coefficients of some binary mixtures of organic vapours have been measured at temperatures between 50 and 120°C. Mixtures of *n*-hexane with chloroform and of *n*-hexane with diethyl ether show a linear variation of second virial coefficient with composition. This is shown to be in accordance with prediction from the principle of corresponding states. Mixtures of chloroform with diethyl ether show a linear variation at 120°C, but pronounced curvature at lower temperatures. This is interpreted quantitatively as being due to association by H bonding with an energy of 6 020 cal/mole. A.

533.7 : 536.7 : 534.22

Determination of thermodynamic and kinetic constants of gases and liquefied gases at low temperatures. *See Abstr.* 2501

533.75 : 533.24

2486. A comparison of Duclaux's new theory of gases with Dieterici's theory. H. H. Paine. *S. Afr. J. Sci.*, **48**, 189–90 (*Jan.*, 1952).

J. Duclaux has developed a theory for explaining that portion of the compressibility of a gas which is in excess of the amount given by Clausius's modification of Boyle's law [see Abstr. 8564 (1950)]. Molecular association is postulated in place of van der Waals' attractive forces. The Dieterici equation of state provides a convenient basis for the comparison of these two postulates. A.

VIBRATIONS . ACOUSTICS 534

534

2487. Introduction to acoustics. [Einführung in die Akustik]. F. Trendelenburg. (2nd ed.). *Berlin, Springer Verlag* (1950) viii + 378 *pp. In German.*

534.1

2488. The accuracy of Rayleigh's method of calculating the natural frequencies of vibrating systems. G. Temple. *Proc. Roy. Soc. A*, **211**, 204–24 (*Feb.* 21, 1952).

A theorem of Kato (1949) which provides upper and lower bounds for the eigenvalues of a Hermitian operator is modified and generalized so as to give upper and lower bounds for the normal frequencies of oscillation of a conservative dynamical system. The method given here is directly applicable to a system specified by generalized co-ordinates with both elastic and inertial couplings. It can be applied to any one of the normal modes of vibration of the system. The bounds obtained are much closer than those given by Rayleigh's comparison theorems in which the inertia or elasticity of the system is changed, and they are in fact the "best possible" bounds. The principles of the computation of upper and lower bounds is explained. A.

534.11

2489. The modes of vibration of a semi-flexible rod under tension. R. W. Kenworthy and V. A. Jennings. *J. Acoust. Soc. Amer.*, **24**, 60–1 (*Jan.*, 1952).

The possible modes of vibration of a rod under conditions which are intermediate between a perfectly flexible string under tension and a stiff bar without tension have been calculated from existing theory. An experimental investigation of the first ten modes gave results in agreement with the theory within approximately 0·5%. Deviation from a harmonic series increases with the number of the mode of vibration, but is considerably less than for a stiff bar. A.

534.121.1

2490. Vibrations of free plates: line symmetry; corresponding modes. M. D. Waller. *Proc. Roy. Soc. A*, **211**, 265–76 (*Feb.* 21, 1952).

The normal modes of vibration of a plate with m lines of symmetry may be divided into $2f$ classes, where f denotes the number of factors of m. The normal vibration patterns of a plate may be arranged on a diagram in which all classes of symmetry recur in every two rows (or one row for the circular plate) and in every m columns. The normal modes of vibration of plates correspond with one another. That is to say, every vibration pattern on one plate has a counterpart on every other plate. The principle of corresponding vibrations can be extended to plates of irregular shape. Combined vibrations must also conform to the symmetry of the plate. A.

534.13 : 534.832

2491. Wave effects in isolation mounts. M. Harrison, A. O. Sykes and M. Martin. *J. Acoust. Soc. Amer.*, **24**, 62–71 (*Jan.*, 1952).

Both theoretical and experimental studies have been made. From the standpoint of vibration isolation, wave effects are important in the sense that the vibration isolating properties of a mount are changed by their presence. The well-known "lumped parameter" theory of vibration mounts predicts that the vibration isolation of a mount increases at 12 db per octave for frequencies well above the resonant frequency of the spring-mass system. This theory holds true only when the wavelength of the elastic wave in the mount is large compared to the dimensions of the mount. Standing waves occur, as would be expected, which in certain frequency ranges decrease the vibration isolation properties of the mount by as much as 20 db. For practical mounts, wave effects are most detrimental in the most audible frequency range (500 to 1 000 c/s). The theoretical and experimental treatments are in good agreement, and indicate various methods for improving the vibration isolation properties of the mount. Experimental data concerning isolation mounts fabricated of various materials are presented. A.

534.133

2492. Forced thickness-shear and flexural vibrations of piezoelectric crystal plates. R. D. Mindlin. *J. Appl. Phys.*, **23**, 83–8 (*Jan.*, 1952).

An approximate theory is given for the vibrations of piezoelectric crystal plates in thickness-shear and flexural modes, including the interaction between the elastic and electric fields. The problem of the

rectangular, AT, quartz plate is solved and computed frequencies are compared with measurements by Sykes. Algebraic formulae are obtained relating resonant frequencies with dimensions, elastic and electric constants, and orientation of cut. A.

534.152

2493. Observations in the standing ultrasonic wavefield. O. A. ANGERER. *Nuovo Cim.*, **7**, 133–4 (*Suppl. No.* 2, 1950) *In German.*

Standing waves in an ultrasonic field in water can be demonstrated by the formation of bands of small air droplets in the zones of compression and by isolated, relatively large vibrating air bubbles in the zones of rarefaction. Well-defined zones are obtained at 30 kc/s when the wavelength in water is 5 cm. When glass or cork spheres of diameter about $\frac{1}{20}$ of the wavelength are used, they move into and indicate the positions of the zones of rarefaction.

A. C. WHIFFIN

534.21

2494. Ultrasonic propagation in the sea. E. PAOLINI. *Nuovo Cim.*, **7**, 402–15 (*Suppl. No.* 2, 1950) *In Italian.*

Firstly data are given for the constants of propagation of ultrasonic waves in pure water, and then the corresponding information is given for salt water showing the effects of salinity and variation of density. In sea water, the pressure and temperature increase with depth and depend on the latitude and the season. The trajectory of a beam of vibrations in the sea is refracted by these variations and formulae are given for computing the trajectory. Formulae are also given for computing the path through water which is in motion. A. C. WHIFFIN

534.21 : 534.374 : 538.551

2495. On the analogy between wave propagation in elastic tubes, acoustic filters and electrical ladder networks. V. HARDUNG. *Helv. Phys. Acta*, **24**, 321–2 (*No.* 4, 1951) *In German.*

534.212

2496. Propagation of elastic waves in a floating ice sheet. F. PRESS AND M. EWING. *Trans Amer. Geophys. Un*, **32**, 673–8 (*Oct.*, 1951).

The characteristic equation for the propagation of elastic waves in a floating ice sheet is derived and discussed, with special emphasis on the evaluation of phase velocity for very large and very small wavelengths. The solutions cannot be reduced to symmetric and antisymmetric modes as in the case of a plate in a vacuum or a liquid. Among the waves discussed are compressional, shear, longitudinal, flexural, Rayleigh, Stoneley and Love waves. A.

534.22/.23 : 532.7

2497. Ultrasonic relaxation processes in pure liquids. J. H. ANDREAE AND J. LAMB. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 1021–31 (*Dec.*, 1951).

The assumptions made by Hall and Herzfeld in previous theories of ultrasonic absorption are interpreted on the basis of a new and more general analysis. The formulae given by them are discussed, and it is suggested that the conditions implicit in Herzfeld's formula should be modified. By this modification a new relation is derived, which provides a satisfactory explanation of the observed relaxation effects in those liquids which have been studied. A method of "curve fitting" is employed to compare experimental results with theoretical requirements. Finally, it is concluded that the ultrasonic behaviour of acetic acid and propionic acid is governed by the excitation of bending vibrations of C–H bonds. Measurements in CS_2 indicate that in this case also a bending vibration is responsible. Some incomplete data for toluene suggests that here a stretching vibration of the C–H bonds in the methyl group is involved. A.

534.22

2498. Sound propagation in gelatinous substances. A. M. SRIVASTAVA. *Kolloid Z.*, **119**, 73–85 (*Nov.*, 1950) *In German.*

The velocity of sound in gelatinous substances is deduced. It is assumed that the solid particles in the fluid medium are solids of revolution about the $\theta = 0°$ axis, of the form given by $r = c \sin p\theta$. An expression for the velocity potential is deduced which is a more general version of the Rayleigh scattering law, to which it will reduce when it is assumed that the particles are spherical. One of the conclusions is that the scattered wave also depends on the form of the particles. Hitherto, other authors have assumed that the form of the particles was immaterial. The mathematical formalism involves solving the equations for the motion inside and outside the solid particles using a series of zonal harmonic functions.

APPLIED MECHANICS REVIEWS

534.22 : 532.7

2499. Ultrasonics and the structure of liquids. W. SCHAAFS. *Nuovo Cim.*, **7**, 286–95 (*Suppl. No.* 2, 1950) *In German.*

Since the amplitude of sound waves is usually small, a formula can be devised relating the velocity of propagation with the ratio of specific heats of gases in combination with van der Waals' equation. The theory shows that the velocity of sound in an organic liquid is proportional to the product of the co-volume (space actually occupied by the molecule) and the collision factor. Additive rules are developed for computing the velocity of sound in mixtures and the results of the theoretical work are shown to be in good agreement with experimental data.

A. C. WHIFFIN

534.22 : 532.77

2500. The velocity of sound in electrolytic solutions. S. BARNARTT. *J. Chem. Phys.*, **20**, 278–9 (*Feb.*, 1952).

A relationship between the velocity of sound in electrolytes and concentration has been derived for extremely dilute solutions from the Debye–Hückel limiting law. The equation fits the observed data at higher concentrations when the theoretical coefficients are replaced by empirical constants. A.

534.22 : 533.7 : 536.7

2501. Determination of thermodynamic and kinetic constants of gases and liquefied gases at low temperatures. A. VAN ITTERBEEK. *Nuovo Cim.*, **7**, 218–28 (*Suppl. No.* 2, 1950) *In French.*

An ultrasonic interferometer is used to determine the velocity of propagation of ultrasound in A–H_2

mixtures at 80–90°K. In general, the velocity rises with the temperature and with increase of the H_2 content. Measurements are made on A–H_2, A–He, H_2–He, O_2–H_2 mixes and the virial coefficients are determined from the results. For a number of organic liquids and for liquefied gases, values are plotted of "r" versus $T_2 - T_1$, where T_2 is the temperature of test and T_1 is the lowest temp. at which tests are made, or, in certain cases, the temp. of solidification. The ratio "r" $= [W_{T_1}^{1/3}/\rho_{T_1}]/[W_{T_2}^{1/3}/\rho_{T_2}]$ where W_T and ρ_T are respectively the velocity and density of the liquid at the temperature T. The experiments show that the only satisfactory relationships are obtained when the index 1/3 is used for the velocity as suggested by Rao, from which it appears that Rao's expression has some significance. Absorption measurements are also made on some of the gases. A. C. WHIFFIN

534.22 : 539.32 : 541.64

2502. The application of ultrasonics to the measurement of the elasticity of high polymers. K. W. HILLIER. *Nuovo Cim.*, 7, 213–17 (*Suppl. No.* 2, 1950).

Materials such as long chain high polymers have elastic properties depending on the rate of loading, and short time intervals can be obtained by employing sinusoidally varying forces derived from electromechanical transducers. Longitudinal oscillations of small amplitude are propagated along filaments of high polymers 1–2 m long, and the velocity of propagation is measured by the phase difference method. A signal obtained from a piezoelectric pick-up, which is moved along the filament, is compared in phase and amplitude with a signal derived from the generator. For polythene, the dynamic modulus increases with strain and frequency and decreases with temperature. The velocity of propagation at 17 kc/s in drawn nylon decreases with rise of temperature.

A. C. WHIFFIN

534.221 : 539.312

2503. Transmission of elastic pulses in rods. D. S. HUGHES AND J. H. STANBROUGH. *Texas J. Sci.*, **3**, 568–76 (*Dec.*, 1951).

The transmission of elastic pulses through solid rods has been investigated. A single input pulse gives rise to a series of pulses from which it has been found possible to compute both the dilatational and rotational velocities in the material. From these velocities the elastic moduli of isotropic materials may be computed. The mode of transformation of the input pulse has been studied and provides a thorough check on the computational procedure. Two materials, Pyrex glass and brass, have been studied. The moduli have been measured as functions of pressure and temperature up to 50 000 lb/in^2 and 200°C. A.

534.222.2 : 536.46

2504. The structure of shock and combustion waves. M. ROY. *C.R. Acad. Sci.* [*Paris*] **234**, 168–70 (*Jan.* 7, 1952) *In French.*

An earlier paper [M. Roy, *C.R. Acad. Sci.* [*Paris*] **218**, 813 (1944)] dealing with the structure of a one-dimensional pure shock wave in a compressible, viscous and thermally conducting fluid is extended to take account of chemical reaction initiated by the shock. The specific heat, Prandtl no., viscosity and thermal conductivity are assumed const., the chemical reaction is supposed continuous, and the effect of thermal radiation is neglected. It is shown that if the space-co-ordinate (x) transverse to the shock front is transformed to the dimensionless variable ξ (where $\xi = 3\rho_1 u_1 x/4\eta$, ρ_1 and u_1 being the gas density and velocity at $x = -\infty$ ahead of the shock, and η the viscosity), the pressure (p), temperature (θ), density (ρ) and stagnation temperature (D) at any point in the shock may be expressed (in terms of their values at $x = -\infty$) as functions of ξ, independent of the viscosity and conductivity of the medium. Two distinct types of wave can arise: (*a*) when the Mach no. M of the wave propagation velocity is low, p is almost const., and ρ varies approx. as θ^{-1}; (*b*) when M is large, ρ is approx. const. in the pre-shock zone, while p varies approx. as θ. Waves of type (*a*) are identified with deflagration flames; those of type (*b*) with quasi-detonation waves. It is found that the temp. distribution $[\theta(\xi)]$ alters very little over the range $M = 0{\cdot}01$ to $M = 9$. The scale of the reduced variable ξ does, however, change appreciably and is so small at $M = 9$ that the pressure increases several times within a distance of one mean free path. This result gives rise to doubt as to the validity of assuming macroscopic continuity. A. SCHOFIELD

534.23

2505. Transmission of ultrasound through porous bodies in liquids. G. VON SCHMID AND H. KNAPP. *Nuovo Cim.*, **7**, 296–301 (*Suppl. No.* 2, 1950) *In German.*

Because of current interest in underwater sound ranging and in medical treatment by ultrasonics, the transmission of sound and ultrasound through saturated, porous bodies in liquids is important. When a weak electrolyte is forced through a fine-pored diaphragm, a streaming potential exists between the two faces of the diaphragm, and this potential becomes alternating when ultrasonic vibrations are set up in the liquid and cause it to move backwards and forwards in the pore spaces. Apparatus has been built to measure this effect experimentally, using N/1 000 KCl solution, special precautions being taken to shield the porous diaphragm electrostatically from the potentials supplied to the ultrasonic transmitter.

A. C. WHIFFIN

534.23

2506. The transmission of ultrasound through plates. A. SCHOCH. *Nuovo Cim.*, **7**, 302–6 (*Suppl. No.* 2, 1950) *In German.*

The transmission by a plate of plane parallel ultrasonic vibrations depends on the frequency, the thickness of the plate and the angle of incidence. Maximum transmission occurs when the velocity with which the wave fronts cut the plate equals the phase velocity of any type of wave which can be set up in the plate. Schlieren photographs show how the transmission varies with plate thickness and angle of incidence. Small damping by the plate gives a strong and broader beam of waves on the rear side of the plate. When very good transmission through the plate occurs, the schlieren photographs show that the reflected wave on the front face disappears.

A. C. WHIFFIN

534.23 : 532.74

2507. An anomalous effect in the ultrasonic absorption of electrolytic solution. R. E. BARRETT AND R. T. BEYER. Letter in *Phys. Rev.*, **84**, 1060–1 (*Dec.* 1, 1951).

The amplitude absorption coefficient has been measured in aqueous solutions of sodium acetate, it being observed that the coefficient is larger than that of water at low frequencies and vice versa. T. C. TOYE

534.23

2508. Absorption of ultrasound in solids. P. G. BORDONI. *Nuovo Cim.*, **7**, 144–60 (*Suppl. No.* 2, 1950) *In Italian.*

The absorption of ultrasound in solids is studied theoretically and experimentally. For elastic waves, the coefficient of attenuation determined experimentally rises to a maximum at a particular frequency and then falls again, and it is shown that the maximum value of the coefficient is given by $2\pi(c_\infty - c_0)/\sqrt{(c_\infty c_0)} = \pi\Delta E/E$. c_∞ and c_0 are the velocities of propagation at frequencies near infinity and zero respectively, E is the modulus of elasticity, and $\Delta E = E_u - E_R$ where E_u = instantaneous value of the modulus, and E_R = Hooke's value. Thermodynamic considerations show that the velocity of propagation (c) at a frequency (ω) is given by $c = (E_{is}/\rho)[\omega^4 D^2 + c^2(E_{is}/E_{ad})]/[\omega^4 D^2 + c^2(E_{is}/E_{ad})^2]$ where D = thermal diffusivity, and E_{is} and E_{ad} are the isothermal and adiabatic elasticities respectively. Maximum thermal absorption occurs when $\omega = 3D/a^2$, where a = grain dia., and this is confirmed experimentally. Studies are made of both monocrystalline and polycrystalline specimens.

A. C. WHIFFIN

534.23

2509. Some considerations on a new effect in absorption. F. GATTO. *Nuovo Cim.*, **7**, 204–11 (*Suppl. No.* 2, 1950) *In Italian.*

Using a probability technique, a study is made of the contribution made to the absorption of ultrasonic waves in a material by the isolated grains. The theoretical work is in general illustrated by experimental data obtained by other workers. The effects are investigated of the amplitude and wavelength of the applied vibrations. A. C. WHIFFIN

534.23

2510. General theory of absorption of sound in gases and liquids. H. O. KNESER. *Nuovo Cim.*, **7**, 231–5 (*Suppl. No.* 2, 1950) *In German.*

The absorption of sound in liquids and gases as measured experimentally is in most cases much larger than expected from the classical theory based on the thermal conductivity and viscosity of the material. A theory of sound absorption is given which is based on plausible, generally accepted assumptions regarding the process of relaxation and which leads to a general absorption formula. A. C. WHIFFIN

534.23

2511. Reverberation measurements in liquids. C. E. MULDERS. *Nuovo Cim.*, **7**, 255–9 (*Suppl. No.* 2, 1950).

Ultrasonic absorption in liquids can be measured by determining the decrease of the intensity of a progressive wave radiated by a suitable source, but complications arise by the additional absorption occurring near and in the walls of the vessel containing the liquid. The liquid is held in an Al vessel of several litres capacity, and two small piezoelectric crystals are coupled acoustically to the bottom by a drop of kerosene. One crystal acts as the transmitter, the other is the receiver. After the transmitter has been run and is switched off, reverberation occurs and its time is determined. The exponential decay is obscured by interference phenomena between the different modes of vibration of the vessel with the liquid. The fluctuations caused by this effect are diminished by using a frequency-modulated signal, a warble-tone 15–20 kc/s wide around the mean frequency of 1 Mc/s.

A. C. WHIFFIN

534.23

2512. Results of experiments to measure the absorption coefficients of ultrasonic waves in mixtures of liquids. D. SETTE. *Nuovo Cim.*, **7**, 318–27 (*Suppl. No.* 2, 1950) *In Italian.*

Measurements of absorption were made at 8 Mc/s, and values of the coeff./freq.^{2} were plotted against the mix proportions. The value fell with increase of the second component in the following two component mixtures: chloroform–toluol, chloroform–methyl alcohol, carbon tetrachloride–acetone, carbon tetrachloride–methyl alcohol, carbon tetrachloride–ethyl alcohol, benzol–ethyl alcohol. A. C. WHIFFIN

534.23

2513. The use of a high-stability magnetostriction oscillator to investigate the amplitude absorption of plane sound waves in narrow glass and metal tubes. D. E. WESTON. *Nuovo Cim.*, **7**, 341–4 (*Suppl. No.* 2, 1950).

The high Q magnetostrictive transducer described by Knight [Abstr. 2531 (1952)] is coupled with an interferometer tube of 0·13 cm dia. and less, the reflecting surface in the tube being provided by a closely fitting metal piston, or, in very narrow tubes, by an adjustable Hg column. The whole apparatus is enclosed in a box having thermostatically controlled air temperature. By observing the position of the piston for maximum reaction on the transducer, the wavelength and the absorption can be determined. The experimental values all lie above those predicted by Kirchhoff's theory, the discrepancy with monel tubes being particularly large and attributable to internal irregularities in the tubes. In general, provided the second-order correction is negligible, the results are consistent with Kirchhoff's law.

A. C. WHIFFIN

534.23

2514. Measurements of ultrasonic absorption in various mixtures of nitrobenzene. D. SETTE. *Ric. Sci.*, **21**, 2167–71 (*Dec.*, 1951) *In Italian.*

To obtain information on the characteristics of relaxation phenomena in liquids, measurements of ultrasonic absorption were performed in 7 binary mixtures having nitrobenzene as one component. The absorption coefficients in some systems (benzene chloroform) confirm the results obtained previously in mixtures formed by an unassociated very absorbing liquid and another component with much smaller absorption coefficient. In this case, the absorption coefficient decreases quickly when small quantities of

the second liquid are added to the first one. The mixtures formed by two components having similar absorption coefficients are of great interest because the behaviour of the ultrasonic absorption depends on the nature of both pure liquids and often relaxation phenomena of various natures seem to be present at the same time. In the systems of nitrobenzene and an alcohol the absorption coefficient as a function of the mole fraction has a maximum at an intermediate concentration, just as happens in some mixtures of water and alcohols. A.

534.23

2515. The absorption and dispersion of sound in oxygen as a function of the frequency-pressure ratio. W. J. THALER. *J. Acoust. Soc. Amer.*, **24**, 15–18 (*Jan.*, 1952).

The velocity and absorption of ultrasonic waves in oxygen were measured by means of an improved ultrasonic interferometer in the range from 1 to 100 Mc/s per atm. Dispersion of the velocity ranged from 333·14 m/sec to 357·22 m/sec at 30°c. The ratio ($\alpha_{exper.}/\alpha_{class.}$) dropped from 3·68 to 2·05, and the corresponding value of C_v/R dropped from 2·50 to 1·61. The increase in velocity and the decrease in ($\alpha_{exper.}/\alpha_{class.}$) is interpreted as caused by the slow exchange of energy between the translational and rotational degrees of freedom. The relaxation time for the rotation was $5{\cdot}24\times10^{-9}$ sec. A.

534.23

2516. Attenuation of sound in water containing air bubbles. D. T. LAIRD AND P. M. KENDIG. *J. Acoust. Soc. Amer.*, **24**, 29–52 (*Jan.*, 1952).

Measurements of the attenuation of sound in water containing air bubbles were undertaken in order to confirm some aspects of a theory due to L. L. Foldy. Bubbles were produced by forcing compressed air through the cloth covering of several trays lying on the bottom of the Black Moshannon Lake. The distribution in size of the bubbles and the number of bubbles per unit volume were determined by photographing the bubbles and by collecting the volume of air which rose over a given area in a given time, the terminal velocity of rise being a known function of bubble diameter. The attenuation of sound was found to be very large at frequencies for which resonant bubbles were present, and much smaller at other frequencies, indicating that resonance absorption was the principal phenomenon observed. For the particular bubble distribution investigated, which contained 0·045% air by volume, the attenuation was found to be in satisfactory agreement with the theory and a maximum attenuation of approximately 20 db per in was measured. Amplitude and phase fluctuations made it impossible to measure the phase velocity, but this quantity was computed from the bubble distribution. A.

534.23 : 532.528

2517. Dependence of ultrasonic absorption on intensity and the phenomenon of cavitation. F. E. FOX. *Nuovo Cim.*, **7**, 198–203 (*Suppl. No.* 2, 1950).

To obtain reproducible results for the coeff. of sound wave absorption in liquids, the tests must be made at low intensities, for it is thought that the increase which occurs at higher intensities may be due to cavitation, even although visible cavitation does not occur until much higher intensities are used. Light scattering experiments have not clearly demonstrated an increase of scattering in intense sound fields. Measurements are made of absorption at 10 Mc/s, the intensity at various distances from the source being measured by a rubber disk detector having a bifilar suspension. Tests are made on water saturated with air, water saturated with carbon dioxide, and gas-free distilled water. In water, the absorption coeff. has the value 44×10^{-3} at intensities up to 0·04 W/cm² and then rises to 190×10^{-3} at 5 W/cm². For water saturated with CO_2, the corresponding coefficients are 44×10^{-3} to 160×10^{-3}. A. C. WHIFFIN

534.23 : 532.74

2518. The origin of the ultrasonic absorption in liquids. II. K. F. HERZFELD. *J. Chem. Phys.*, **20**, 288–9 (*Feb.*, 1952).

Excess absorption in non-associated liquids has been explained by the same mechanism as is responsible for molecular absorption in gases, namely, slow exchange of energy between internal and external degrees of freedom. In this paper the rate of energy exchange is calculated for benzene and found to be three times too rapid. The Lennard–Jones interaction potential and model of the liquid are used; the fourth-order terms in the interaction provide the coupling between internal vibrations and Debye waves. A.

534.23 : 535.41

2519. A precise recording ultrasonic interferometer and its application to dispersion tests in liquids. R. BARTHEL AND A. W. NOLLE. *J. Acoust. Soc. Amer.*, **24**, 8–15 (*Jan.*, 1952).

A precise recording ultrasonic interferometer is presented which is particularly well suited for measuring dispersion in liquids. The device is an interferometer of the two-crystal type in which the separation of the crystals is continuously varied. The recording process is equivalent to placing a mark on a rotating recording drum whenever the receiving crystal has moved a distance of one wavelength of sound in the liquid. Thus the wavelength of sound may be derived from the known mechanical constants of the system. The precision of the dispersion measurement is about 0·8 part in 10 000; the precision of the absolute determination of sound velocity is 0·1 m/sec. The instrument has been applied also to sound velocity measurements in solids under restricted conditions. Sound velocity in distilled water at 25°c as measured with this instrument is $1\,496{\cdot}2 \pm 0{\cdot}2$ m/sec, a value somewhat lower than that obtained by earlier investigators. Dispersion in the frequency range 5–25 Mc/s is shown to be no greater than 0·8 part in 10 000, the limit of experimental error, for all the liquids studied: water, geraniol, xylene, isobutyl alcohol and solutions of sucrose, NaCl, $MgSO_4$, $NaHCO_3$, $CdCl_2$, $CdSO_4$, Na_3PO_4, $Pb(NO_3)_2$, $ZnSO_4$ and $K_3Fe(CN)_6$. A.

534.23 : 535.41

2520. On the theory of the fixed path acoustic interferometer. F. E. BORGNIS. *J. Acoust. Soc. Amer.*, **24**, 19–21 (*Jan.*, 1952).

A general expression is given for the electric input impedance of the acoustic interferometer. From this

expression formulae are derived for determining the velocity of sound by varying the frequency, or for determining changes in velocity due to variations of pressure, temperature, etc. In papers dealing with the fixed path interferometer, one commonly finds the suggestion that the actual path length needs some correction when the path ends at a non-perfect reflector. It will be shown that no such correction is indicated by the theory. A.

534.23 : 535.41

2521. A recording ultrasonic interferometer and its alignment. J. L. STEWART AND E. S. STEWART. *J. Acoust. Soc. Amer.*, **24**, 22–6 (*Jan.*, 1952).

The first part is the description of a circuit employing r.f. amplification which converts an ultrasonic interferometer into a sensitive self-recording instrument whose records can be simply analysed to yield a rapid determination of the attenuation and reflection coefficients of gases at low pressures. The second part is a summary of the sources of error in ultrasonic interferometry, their detection and their correction. In the third part, some data on the velocity, attenuation and reflection in He in the region 2 to 60 Mc/s per atmos. are presented to illustrate the range, precision and absolute errors of the instrument. A.

534.23 : 535.41

2522. The use of glass parts in ultrasonic interferometers. R. T. LAGEMANN. Letter in *J. Acoust. Soc. Amer.*, **24**, 86 (*Jan.*, 1952).

Two ways are mentioned of adapting a Pyrex cup to give electric and acoustic contact with a quartz oscillator, and thus enable interferometric measurements to be made on corrosive liquids. G. F. HODSMAN

534.23 : 539.312

2523. The attenuation of elastic waves in tin and lead-tin alloys. P. G. BORDONI AND M. NUOVO. *Nuovo Cim.*, **7**, 161 (*Suppl. No.* 2, 1950) *In Italian.*

Tests in the range 10–25 kc/s show that technically pure Sn has an internal friction increasing linearly with temperature but with marked discontinuities at the transition point, 160°, from β-Sn to γ-Sn. At ordinary temperatures, the internal friction increases with increase of the Pb content within the range studied (Pb $\leqslant$ 10%). A. C. WHIFFIN

534.231

2524. Directionality patterns for acoustic radiation from a source on a rigid cylinder. D. T. LAIRD AND H. COHEN. *J. Acoust. Soc. Amer.*, **24**, 46–9 (*Jan.*, 1952).

The directionality patterns produced by an acoustic source located on a rigid cylinder of infinite length have been investigated for the case in which the source strength may be represented as a separable function of azimuth angle and axial dimension. It is observed that the pattern in a plane orthogonal to the axis of the cylinder is independent of the axial distribution of the source, and is, in fact, identical with the pattern given by Morse for a source of infinite axial extent. For the particular case in which the ratio of circumference to wavelength is 14, patterns in this plane have been computed numerically using an IBM Card-Programmed Calculator. Patterns in a plane containing the axis of the cylinder have also been investigated. A.

534.231 : 535.371

2525. New methods of ultrasonoscopy and ultrasonography. P. J. ERNST AND C. W. HOFFMAN. Letter in *J. Acoust. Soc. Amer.*, **24**, 87 (*Jan.*, 1952).

The use of temperature-sensitive chemicals, thermostimulable phosphors and temperature-sensitive phosphors for visualizing and recording ultrasonic field patterns is mentioned. G. F. HODSMAN

534.231.3

2526. Radiation impedance of a rigid square piston in an infinite baffle. G. W. SWENSON, JR AND W. E. JOHNSON. Letter in *J. Acoust. Soc. Amer.*, **24**, 84 (*Jan.*, 1952).

Computation by evaluating the integral in terms of an infinite series is compared with a punched-card machine method where the area of the piston is divided into 400 parts and all possible values of the distance between the centres of any two elements are determined. Close agreement was found for the real component, but errors up to 30% occurred in the reactive component. G. F. HODSMAN

534.231.3

2527. The absorption coefficient of a porous plate. R. TAKEUCHI AND T. SHINDO. *Mem. Res. Inst. Acoust. Sci. Osaka*, **2**, 28–33 (*March*, 1951).

Measurements have been made of the normal acoustic impedance of porous plates made from pulp. Results are given for various densities, thicknesses and temps. at 500 c/s, using the Beranek method. [See Abstr. 132 (1941)]. The real part of the impedance is expressed by the flow resistance in the pore and the thickness of the sample and the imaginary part by the porosity and the thickness. G. F. HODSMAN

534.231.3 : 534.232

2528. Acoustic impedance transfer by piezoelectric oscillators. K. VON SANDEN. *Nuovo Cim.*, **7**, 284–5 (*Suppl. No.* 2, 1950) *In German.*

When a plane sound wave strikes normally upon a reflecting surface behind which is a medium of differing acoustic properties, part of the sound energy is reflected and part passes into the second medium. The classical theory neglects the fact that the reflected wave returns to the transmitter and forms a combination of stationary and progressive waves. Many piezoelectric transmitters are multi-layered, consisting of an active layer, the crystal, and a passive layer, its metal holder, and both take part in the effective impedance. A. C. WHIFFIN

534.232

2529. The generation of high intensity ultrasonics. A. J. KING. *Nuovo Cim.*, **7**, 129–30 (*Suppl. No.* 2, 1950).

A 200 kc/s piezoelectric source has been developed, of 700 W, working with a peak voltage across the crystal of 37 000. The X-cut quartz crystal is of 5 cm dia. and rests on a Pb block. It is loaded mechanically and insulated electrically by transformer oil. The intensity of radiation is 44 W/sq. cm. Electrode disintegration has been overcome by using Al foil 0·05 mm thick, damping being avoided by cutting a small hole in its centre. A magnetostrictive generator operating at 10 kc/s, and fed by a 30 W oscillator, has been developed, consisting of a hard-

drawn Ni tube 22 cm long, 2·2 cm outside dia., with a wall thickness of 1·6 mm. A. C. WHIFFIN

534.232

2530. Notes on experiments connected with magnetostrictive apparatus. A. SELLERIO AND D. BARBARO. *Nuovo Cim.*, **7**, 314–17 (*Suppl. No.* 2, 1950) *In Italian.*

Details are given of the working parts and frequency range of an American magnetostrictive generator. A. C. WHIFFIN

534.232

2531. An improved design of high Q magnetostriction oscillator for use in acoustic interferometer measurements. J. J. KNIGHT. *Nuovo Cim.*, **7**, 392–5 (*Suppl. No.* 2, 1950).

In designing an acoustic interferometer, it is essential that the transducer shall respond to small changes in acoustic impedance of the gas column when the reflecting plate is moved—such a transducer is described. After many tests, perfectly machined monel rods with plane ends perpendicular to the length were found to have the highest Q. It appeared that the reduced eddy current and hysteresis losses associated with using split tubes were not compensated for by the inability to produce accurately formed specimens. A low damping clamp was devised for centrally mounting the monel rod, the mounting allowing radial motion. The value of Q obtained fell with increase of the polarizing field from 250 to 600 gauss and then rose sharply to attain a maximum at the highest field employed. A. C. WHIFFIN

534.232

2532. A new type of ultrasonic generator for medical purposes. I. H. OTS. *Nuovo Cim.*, **7**, 396–401 (*Suppl. No.* 2, 1950) *In French.*

The generator can be used with either a continuous or a pulsed output, the active and quiescent pulses being independently variable within the range 0·3 to 30 sec. Some forms of medical treatment need the thermal effect produced by an ultrasonic vibration, in which case the continuous output is employed. Other types of treatment need the high frequency without the thermal effect, and then the pulsed output is used. A. C. WHIFFIN

534.232

2533. The general theory of the acoustic transmitter and receiver, its use to obtain the equivalent circuit diagrams of a magnetostrictive oscillator and a quartz transducer. A. SKUDRZYK. *Nuovo Cim.*, **7**, 416–34 (*Suppl. No.* 2, 1950) *In German.*

A study is made of the resistance to movement of a membrane, leading to the equations of motion of a membrane in a magnetic field. The equations of motion are then developed for a magnetostrictive transducer. Allowance is then made for the relaxation losses in the cases of both magnetostrictive and piezoelectric transducers and the equivalent circuit diagrams are deduced. A. C. WHIFFIN

534.232

2534. The design of optimum directional acoustic arrays. N. DAVIDS, E. G. THURSTON AND R. E. MUESER. *J. Acoust. Soc. Amer.*, **24**, 50–6 (*Jan.*, 1952).

A transducer array has been designed according to underlying theory originally applied to broadside electromagnetic aerial arrays by Dolph. The properties of Chebyshev polynomials have been employed to obtain an optimized relationship between minor-lobe level and main beam width. The shading design of a 130 element circular array is carried out utilizing a distance between stack centres of $5\lambda/8$. Experimental measurements of the resulting transducer give a peak sensitivity of −70 db below 1 volt for a field of 1 dyne per cm^2, 11 degrees main beam width at the 3 db down points and suppression of side lobes to more than 32 db below peak sensitivity. A.

534.232 : 537.228.1

2535. Some experiments with barium titanate. G. BRADFIELD. *Nuovo Cim.*, **7**, 182–9 (*Suppl. No.* 2, 1950).

Materials having piezoelectric properties are usually single crystals, but barium titanate is polycrystalline with small, randomly oriented grains. After manufacture by a ceramic process, the material can be polarized in any desired direction. Piezoelectric activity, expressed as the ratio of the stored mechanical energy due to polarization to the stored electrical energy, is about 100 times greater for barium titanate than for nickel or quartz. The titanate exhibits a hysteresis effect in the relation of piezoelectric constant to applied field, and experiments indicate that the process operating has a relaxation time of several minutes. The capacity changes about 6 times as fast as the p.e. const. Small amounts of impurity increase the coercive force of titanate specimens. Details are given of various types of barium titanate transducer, it being considered sufficiently robust and non-hygroscopic to replace Rochelle salt for many purposes. A. C. WHIFFIN

534.232 : 621.395.623 : 621.317.39

2536. Inductance-type transducer and its applications. J. YAMAGUCHI AND Y. SAKURAI. *Techn. Rep. Osaka Univ.*, **1**, 201–12 (*Oct.*, 1951).

The "variable-gap inductance-type transducer" is used as the pick-up in measurement of length, pressure and mechanical vibration. In this paper the fundamental considerations and practical applications of this transducer are described. The sensitivity of this transducer depends on the frequency of electrical source which is supplied to the transducer and the exciting current of inductance coil, and the adequate values of these are shown in the case of a micrometer. Next, in the measurement of dynamic pressure or acceleration the relation between these mechanical quantities and gap length is discussed theoretically. As practical applications the ultra-micrometer, pressure recorder and acceleration meter are described. By the ultra-micrometer the diameter of a steel ball can be measured with sensitivity 1/20 μ. The pressure recorder is applied to the measurement of dynamic pressure between pantograph and trolley wire and as an acceleration meter for vehicles. These instruments are stable, use light transducers of small size and robust construction, and are suitable for telemetering. They are thus suitable for field testing. A.

534.24

2537. A note on critical reflections of elastic waves at free surfaces. J. N. GOODIER AND R. E. D. BISHOP. *J. Appl. Phys.*, **23**, 124–6 (*Jan.*, 1952).

The wave motion in an elastic solid given by the

theory of reflection at a free surface is evanescent for certain conditions—a *P* (plane irrotational) wave at grazing incidence and also an *SV* (plane equivoluminal) wave at grazing incidence. It is shown that by the application of suitable limiting processes wave motions can be obtained for these critical circumstances. The relation of these motions to the non-critical motions is analogous to the relation of critically damped to non-critically damped vibrations.

A.

534.24 : 535.313

2538. Equi-reflecting surfaces. C. CODEGONE. *Atti Accad. Sci. Torino, I*, **85**, 223–6 (1950–51) *In Italian.*

A study of the problem of designing a curved reflecting surface so that the total sound or illumination received on another given surface, both directly and by reflection, shall be uniform when the source has the form of a line bent into an arc of a circle.

J. W. T. WALSH

534.24 : 539.219

2539. The present position in Switzerland of non-destructive testing techniques employing ultrasound. R. V. BAUD AND E. BEUSCH. *Nuovo Cim.*, **7**, 364–75 (*Suppl. No.* 2, 1950) *In German.*

The echo technique is used to locate flaws in specimens and also to check porosity. The resonance technique is used to measure the thicknesses of parts when below 1–1½ cm.

A. C. WHIFFIN

534.24 : 539.219

2540. The use of ultrasonics, in the aluminium industry, for the detection of defects. E. G. STANFORD. *Nuovo Cim.*, **7**, 446–54 (*Suppl. No.* 2, 1950).

A Hughes flaw detector is used for routine examination of extruded bars. With rectangular sections, the bars travel along on rollers, the surfaces are wiped with lanolin, and an operator holds wedge-shaped transducers against one surface. With round bars, the specimens rotate in a cradle as well as travel along. An ultrasonic frequency of 2·5 Mc/s is used, giving a wavelength of 0·1 in, and at this frequency it is easy to detect flaws not more than 0·04 in wide. A higher power unit giving 1·5 kV across the transmitting crystal instead of the normal 230 V is used for testing porous billets.

A. C. WHIFFIN

534.26

2541. Scattering of sound waves by grating. R. TAKEUCHI. *Mem. Res. Inst. Acoust. Sci. Osaka*, **1**, 1–5 (*Feb.*, 1950).

Formulae are derived for the decrease in intensity of sound waves at a point, due to the use of an acoustic grating on the reflecting surface. Two types of grating element are considered and the results are compared with experiments over a frequency range of 10–40 kc/s.

G. F. HODSMAN

534.26

2542. Diffraction of a sound wave by a circular aperture. J. AWATANI. *Mem. Res. Inst. Acoust. Sci. Osaka*, **2**, 14–20 (*March*, 1951).

A theoretical treatment is given for the case where the sound wave is incident at any angle to the aperture. The transmission coefficient is shown to depend on the ratio of the circumference of the aperture to the wavelength and on the angle of incidence if this ratio is large. The significance of the result in room acoustic measurements is briefly mentioned.

G. F. HODSMAN

534.26

2543. The diffraction of a plane sound pulse incident normally on a regular grating of perfectly reflecting strips. E. N. FOX. *Proc. Roy. Soc. A*, **211**, 398–417 (*March* 6, 1952).

In previous papers, solutions and numerical results were obtained for two-dimensional sound pulses incident on (i) an infinite uniform strip [Abstr. 3661 (1948)] and (ii) an infinite uniform slit in a perfectly reflecting screen [Abstr. 6037 (1949)]. A general method given in the latter paper is now used to obtain an exact solution, corresponding to successive diffraction waves, for the case of a plane sharp-fronted pulse of constant unit pressure incident normally on a regular grating of perfectly reflecting strips. An asymptotic solution is also obtained for use in the later stages when numerical evaluation of the exact solution becomes unmanageable owing to the large number of diffraction waves involved. Numerical calculations have been carried out for $\beta = \frac{1}{2}, \frac{1}{3}$ and $\frac{1}{4}$, where β is the aperture area expressed as a fraction of the total grating area. It is found that the average pressures on the two faces of the grating are relatively independent of β provided $\beta \geqslant \frac{1}{4}$, i.e. for gratings having 50% or more aperture area; for such gratings, the pressure is first equalized at time $t = 2b/c$, where $2b$ is the width of a strip and c is the velocity of sound, and subsequently the average pressure on the back of a strip overshoots the incident pressure by a maximum of about 12%, while the average pressure on the front drops to a minimum of 12% below the incident pressure. For gratings with smaller aperture areas in the range $\frac{1}{2} > \beta \geqslant \frac{1}{4}$, the time to first equalization is only delayed slightly beyond time $t = 2b/c$, but the magnitude of the overshooting is appreciably reduced as the fractional aperture area decreases. For much smaller values of β the overshooting becomes negligible and the equalization of pressure on the two faces of the grating becomes asymptotic rather than oscillatory in character. The transmitted pressures at some distance to the rear of the grating will form an effectively plane pulse which will exhibit a sharp front, of magnitude β, followed by a pressure rise which may overshoot the incident pressure of unity. This overshooting of transmitted pressure attains its greatest value, of magnitude 6%, when $\beta = \frac{1}{2}$ and is small for both large apertures ($\beta \to 1$) and small apertures ($\beta \to 0$). Correspondingly, the reflected pulse at some distance to the front of the grating will exhibit a sharp front of magnitude $1 - \beta$ and may contain a negative phase of magnitude up to 6% of the incident unit pressure. The asymptotic solution becomes more accurate as β decreases and should be useful for gratings with small fractional aperture area; especially as in these cases the exact solution would become extremely laborious to evaluate at a relatively early stage when pressures to the rear of the grating are still small.

A.

534.26 : 538.566

2544. Multiple scattering of radiation by an arbitrary configuration of parallel cylinders. V. TWERSKY. *J. Acoust. Soc. Amer.*, **24**, 42–6 (*Jan.*, 1952).

A formal solution in terms of cylindrical wave-functions is obtained for the scattering of a plane acoustic or electromagnetic wave by an arbitrary configuration of parallel cylinders which takes into account all possible contributions to the excitation of a particular cylinder by the radiation scattered by the remaining cylinders. The solution, satisfying any of the usual prescribed boundary conditions simultaneously at the surface of each cylinder, is expressed as the incident wave plus a sum of various orders of scattering. The first order of scattering (the usual single scattering approximation) results from the excitation of each cylinder by only the plane wave or primary excitation. The second order results from the excitation of each cylinder by the first order of scattering from the remaining cylinders, and so on to an infinite order of scattering. The first order, therefore, consists of waves scattered by one cylinder; the second order of waves scattered by two cylinders, etc. The scattering coefficients of the mth order of scattering are expressed recursively in terms of the previous orders, and finally as sums of products of m scattering coefficients of the single cylinder and Hankel and trigonometric functions depending on the geometry of the configuration. A.

534.321.3

2545. The true occidental musical scale. H. A. VUYLSTEKE. Letter in *J. Acoust. Soc. Amer.*, **24**, 87 (*Jan.*, 1952).

A discussion of twelve possible major scales (4 of the Helmholtz type, and including the C-major scale of Pythagorus established mathematically about 500 B.C.). A. B. WOOD

534.321.4 : 612.85

2546. Differential sensitivity of harmony. I. Y. MAKITA AND O. KITAMURA. *Mem. Res. Inst. Acoust. Sci. Osaka*, **1**, 43–8 (*Feb.*, 1950).

Defined as the minimum change in the freq. of one of two harmonic tones of a given interval, necessary to make the sound heard as different in the sensation of harmony. In the first of two experiments, the sounds are heard by the observers from a loudspeaker, and in the second, each component is presented separately to the ears of one of the subjects, using earphones. The differential sensitivity becomes smaller as the sensation level is increased and is larger for a major second interval than consonance at the higher sensation levels. The implications of the different results of the two experiments on the space and time theories of pitch perception are briefly considered. G. F. HODSMAN

534.321.9

2547. Research on ultrasonics at the "O. M. Corbino" Institute. A. GIACOMINI. *Nuovo Cim.*, **7**, 81–91 (*Suppl. No.* 2, 1950) *In Italian.*

The "O. M. Corbino" Institute in Rome is the first national institution for studying ultrasonics. In experiments on electrolytic solutions it has been found that the velocity of ultrasonic waves increases with concentration for salts such as $CdSO_4$ and $Ca(ClO_4)_2$ but falls in the case of $Pb(NO_3)_2$. Increase of alcohol content in water/alcohol mixtures causes a rising ultrasonic velocity/temperature relation to change to the falling curve characteristic of ethyl alcohol. The dynamic modulus of elasticity of Al, determined by the ultrasonic technique, falls by 25% when the purity is raised from 99·00 to 99·7% and then rises again by 5% at 100% purity. Longitudinal resonance tests on single crystals of Cu at 40 kc/s showed that the logarithmic decrement varied with the temperature of test and attained a maximum at $T/\theta = 0{\cdot}29$ where $\theta = 315°K$. Arrangements are described for rendering visible ultrasonic vibrations in air. A. C. WHIFFIN

534.321.9

2548. Ultrasonics in science and industry. L. BERGMANN. *Nuovo Cim.*, **7**, 97–115 (*Suppl. No.* 2, 1950) *In German.*

A summary is given of the present position of ultrasonics in pure science and industry, the material being largely confined to descriptions of the various forms of apparatus which have been developed. The equipment described includes ultrasonic sirens, piezoelectric and magnetostrictive generators, a balance for measuring the pressure of ultrasonic waves, various forms of interferometer, instruments for measuring velocity and absorption by the impulse technique, flaw detectors and the ultrasonic soldering iron. Descriptions are also given of Bergmann's photographs by polarized light of the vibrations of glass rods. A. C. WHIFFIN

534.321.9

2549. Ultrasonics in everyday life—research and analysis. P. CHAVASSE AND R. LEHMANN. *Nuovo Cim.*, **7**, 116–23 (*Suppl. No.* 2, 1950) *In French.*

Measurements have been made using a piezo-electric microphone and a frequency analyser to determine the amplitude and frequency of many of the common noises occurring in daily life. The apparatus covers the range 50 c/s to 100 kc/s. Illustrations from the records obtained include the ultrasonic spectra produced by telephone bells, bunches of keys, electric drills, centrifugal compressors, turbo-reactors, bees in a hive and the sounds heard in a tropical forest. All these records show considerable components at ultrasonic frequencies. A. C. WHIFFIN

534.321.9

2550. Why ultrasonics? H. HECHT. *Nuovo Cim.*, **7**, 124–8 (*Suppl. No.* 2, 1950) *In Italian.*

The three equations (*a*) stress/strain for a body, (*b*) velocity in a resistive medium, and (*c*) acceleration under a sinusoidal force are considered and their implications discussed. When (*a*) is considered at ultrasonic frequencies, high-frequency stress/strain relations can be obtained, thus providing facilities for high-speed fatigue tests—the apparatus for such tests is costly but time-saving. When ultrasonic vibrations are used in medical treatment, it seems that the operative factor is either the pressure of the waves or their velocity. If the effect does not depend on amplitude, but only on velocity, then obviously it is advantageous to use ultrasonic frequencies. Similarly,

if emulsions of materials, segregation of them, and medical treatment, depend on particle acceleration and not on amplitude, then ultrasonic frequencies offer considerable advantages. A. C. WHIFFIN

534.321.9

2551. Experiments on ultrasonics in physics practical classes. E. MEYER. *Nuovo Cim.*, **7**, 248–58 (*Suppl. No.* 2, 1950) *In German.*

Three experiments are described: (1) measurement of the velocity of ultrasound in water in a tube, using an optical method to determine the wavelength—the variation of velocity with temperature is studied; (2) measurement of the absorption of ultrasound in CO_2 using an interferometer, and (3) spark photography of the waves generated in water by a vibrating body. A. C. WHIFFIN

534.321.9

2552. The control of the impregnation of laminated materials by means of ultrasonic techniques. G. A. HOMES AND I. H. OTS. *Nuovo Cim.*, **7**, 385–91 (*Suppl. No.* 2, 1950) *In French.*

The quality of the impregnation of laminated insulating materials made of paper can be controlled by ultrasonic techniques. Measurements of relative intensity of the ultrasound emerging from equal thicknesses of solid and laminated material having no impregnation gave intensities in the ratio 1 000 : 0·01. When thoroughly impregnated, the emergent intensity from a similar thickness of laminated material was 90, while half the thickness gave a value of 100. Lower intensities were given by impregnated, laminated material where the adhesion between layers was poor, the fall in intensity being considerable. The method can be used for routine checking of the materials.

A. C. WHIFFIN

534.321.9 : 539.312

Examination of metallic alloys by ultrasonics. *See Abstr.* 3029

534.37 : 534.844

2553. Discussion of the paper by H. B. Miller on the growth and decay of sound. D. MINTZER. Letter in *J. Acoust. Soc. Amer.*, **24**, 86 (*Jan.*, 1952).

See Abstr. 8602 (1951). A short mathematical note considering the case where the pulse-length of the sound is equal to N times the delay. In Miller's case $N = 1$. A. B. WOOD

534.374 : 534.78

2554. Frequency-band multiplication or division and time-expansion or compression by means of a string filter. F. VILBIG. *J. Acoust. Soc. Amer.*, **24**, 33–9 (*Jan.*, 1952).

An exact relationship between the input and output frequencies has been shown. Two different methods have been used. The first multiplies frequencies by rectification with the aid of a push-pull electrostatic pick-up. Alternating plus-minus polarizing techniques are employed to suppress the undesirable sum frequencies. The resolution of such a doubling system, which will not pass the sum frequencies, is approximately 1·5 times the bandwidth of the single filters. However, the bandwidth is limited by the transit time of speech. The second method multiplies and divides by exciting the harmonics or subharmonics of the single strings. This is done by employing light, stiff "fingers" to disturb the free oscillations of the damped strings. The excitation and the resulting frequency band division and multiplication are investigated. It is shown that in order to get time compression or expansion, it is only necessary to record the multiplied or divided frequency bands and play them back with the corresponding diminished or increased speeds. The results given have a general application to similar type filters such as reed, crystal or magnetostrictive. A.

534.39

2555. The radiation pressure of acoustic waves. R. LUCAS. *Nuovo Cim.*, **7**, 236–47 (*Suppl. No.* 2, 1950) *In French.*

The mechanical action of acoustic waves, whether plane or spherical, progressive or stationary, is calculated by various techniques confirming their tensorial character. A. C. WHIFFIN

534.39

2556. Ultrasonic reactions in spirituous liquids. W. SPECHT. *Nuovo Cim.*, **7**, 435–45 (*Suppl. No.* 2, 1950) *In German.*

The possibility of using ultrasonic vibrations to accelerate ageing and fermentation of spirits first became practical when it was possible to develop a generator of 300 W output operating at 1 Mc/s. Experiments made on volumes of 100 litres, and checked on 1 000 litres, show that the acetic content of wine increases with the duration of the ultrasonic treatment. The ester content of most types of spirit increases with duration of treatment, attains a maximum and then decreases again. Some months after treatment there is little difference between the effects produced by the various durations of treatment.

A. C. WHIFFIN

534.4

2557. On the theory of optical sound analysis. II. J. PICHT. *Ann. Phys.* [*Lpz.*] **9**, 381–400 (*No.* 8, 1951) *In German.*

For Pt I, see Abstr. 5642 (1950). The formulae, derived in Pt I and dealing with determination of complex sound by consideration of phase relationship of individual frequencies, are here expanded. Application of these formulae to a special case of complex sound is also demonstrated. W. W. GEHR

534.414

2558. The free vibrations of a gas contained within a spherical vessel. H. G. FERRIS. *J. Acoust. Soc. Amer.*, **24**, 57–60 (*Jan.*, 1952).

Numerical values of the lowest 84 natural frequencies of vibration for the spherical acoustic resonator are calculated and listed in appropriate tables. Consideration is given to the geometrical structure of the nodal surfaces associated with each mode of vibration and to the degeneracy of each natural frequency. A.

534.422

2559. Contribution to the study of the Hartmann siren. M. PALMÉ. *Nuovo Cim.*, **7**, 260–77 (*Suppl. No.* 2, 1950) *In French.*

A Hartmann siren is produced when gas is forced through a jet at such a high pressure that the gas emerges at the speed of sound and a resonator is placed

in the zone where the jet of gas is growing—actually the jet presents a periodic structure with its diameter periodically growing and diminishing. Drum camera photographs were taken of the jets of gas and confirmed the theory of the operation of the siren. A resonant tube filled with smoke was used to check the wavelength produced, and a mechanical radiometer was employed to measure the intensity of the ultrasound. The intensity increased with the pressure of the gas supply and rose to a maximum at 7 kg, the highest maximum being given by a convergent orifice. Various forms of resonator were studied.

A. C. WHIFFIN

534.61

2560. Measurement of the intensity of high frequency sound waves by the principle of similarity. J. AWATANI AND H. OTSUKA. *Mem. Res. Inst. Acoust. Sci. Osaka*, **1**, 54–60 (*Feb.*, 1950) *In Japanese.*

The absolute intensity measurement of high-frequency sound waves presents some difficulties due to the relatively short wavelength. However, it is possible to eliminate them over almost any high-frequency range by employing the principle of similarity. Two similar crystal microphones with linear dimensions in the ratio of 2 : 1 were constructed. By this principle, the shape of the response frequency characteristic of a small microphone is the same as that of the large one, but advanced one octave in frequency. Thus, by use of the small microphone, it is possible to measure the intensity of high-frequency sound waves. In addition the pressure of the sound waves due to a Galton whistle was measured up to 20 kc/s by this method. A.

534.61

2561. The present position of the measurement of sound load and intensity. F. SEIDL. *Nuovo Cim.*, **7**, 307–13 (*Suppl. No.* 2, 1950) *In German.*

In much experimental work it is difficult to decide whether the results observed are due to frequency or amplitude, hence the need to determine intensity. The Rayleigh disk type of radiometer, or a quartz receiver placed in the field, both affect the intensity in the direction of propagation and cause a pressure gradient. Various probe type pick-ups are described and details are given of a funnel-shaped receiver having an aperture of 1·5 mm dia. and containing a quartz crystal 6 mm in dia. Typical results are given, indicating that the funnel receiver is satisfactory.

A. C. WHIFFIN

534.61

2562. Apparatus for measuring the intensity of modulated ultrasound. A. BARONE AND M. NUOVO. *Nuovo Cim.*, **7**, 359–63 (*Suppl. No.* 2, 1950) *In Italian.*

Formulae are derived for the voltage generated by a microphone placed in a beam of modulated ultrasound in order to measure the intensity of the vibration. Brief details are given of apparatus which has been developed, and a typical calibration curve is given showing that, for petrol, using an ultrasonic beam of 2 Mc/s, modulated at 1 kc/s, the anode current of the valve to which the microphone is fed is linearly related to the intensity of radiation.

A. C. WHIFFIN

534.612.3

2563. The effect of the back electrode of a condenser microphone, in the case of sound pressure measurement by compensation method. K. KATO. *Mem. Res. Inst. Acoust. Sci. Osaka*, **1**, 49–53 (*Feb.*, 1950) *In Japanese.*

The diameter of the back electrode of the condenser microphone must be less than the diameter of the diaphragm and the back electrode not completely parallel to the diaphragm. In such cases, the relation between the sound pressure to be measured and the compensating pressure is not independent of frequency. In this paper, the dependence on frequency of the relation between the sound pressure to be measured and the compensating pressure is described.

A.

534.612.3

2564. On the sound pressure measurement by means of a compensation method used a Rochelle salt crystal. K. KATO. *Mem. Res. Inst. Acoust. Sci. Osaka*, **2**, 1–7 (*March*, 1951).

The relation between sound pressure and compensating pressure (the electrostatic force necessary to stop the vibration of a diaphragm) is deduced theoretically and the conditions under which it is independent of freq. are deduced. Results of experiments in the freq. range 0–5 kc/s confirm some of the theoretical predictions. G. F. HODSMAN

534.613

2565. On the effect of the thickness of a pipe upon the moment of a Rayleigh disc. J. AWATANI. *Mem. Res. Inst. Acoust. Sci. Osaka*, **1**, 28–32 (*Feb.*, 1950).

A theoretical calculation is compared with measurements in the range 0–7 kc/s in pipes of 5, 15, 25 mm wall thickness, a length of 20 mm and an inner dia. of 30 mm. Close agreement is found except below 1 kc/s, where the assumptions in the theory may not be valid. The effect of wall-thickness is appreciable—particularly at low frequencies. G. F. HODSMAN

534.613

2566. Anomalous action of Rayleigh disc. K. KATO AND J. AWATANI. *Mem. Res. Inst. Acoust. Sci. Osaka*, **2**, 8–13 (*March*, 1951).

The effect observed by Skinner [*Phys. Rev.*, **27**, 346 (1926)] is shown to be due to the horizontal component of the particle velocity of the standing wave in the pipe due to reflection by the disk itself. Small apertures bored in the wall of the pipe are shown to be effective in removing the effect. If the pipe diameter is large compared to the disk diameter, the effect arises at lower freqs. but is only appreciable if the wavelength is larger than the disk diameter.

G. F. HODSMAN

534.614

2567. Optical method for measuring the velocity of ultrasonic longitudinal and transverse waves in solids. A. BARONE. *Nuovo Cim.*, **7**, 135–43 (*Suppl. No.* 2, 1950) *In Italian.*

The solid under investigation is made into a rectangular prism with one end face cut at 45° to its axis. The prism is immersed in a liquid of known acoustic properties and longitudinal waves are excited in it by a quartz disk attached to one of the side faces so that the beam of waves generated normal to the

face strike the 45° end face. Some longitudinal waves pass from the solid into the liquid and are refracted at the solid/liquid interface. The longitudinal waves are also reflected and travel along the axis of the prism, while transverse waves are reflected at a different angle, travel in the solid and then emerge and are refracted at a point on the face carrying the quartz disk. The various angles are determined from photographs of the prism in the liquid, and the velocities are computed from the angles of refraction.

A. C. WHIFFIN

534.614

2568. Precise measurement of velocity and attenuation using ultrasonic waves. G. BRADFIELD. *Nuovo Cim.*, **7**, 162–81 (*Suppl. No.* 2, 1950).

Attenuation is the small imaginary component of a complex velocity, the real part being the phase velocity. Consequently, it is possible to measure velocity to 1 part in 2 000 and attenuation to only 1 in 100. Guided waves are used in measurements of velocity in liquids in solid-walled tubes and in solids in the form of bars, strips or tubes. Diffracted waves are used in some experiments and involve radiating elements and receivers several wavelengths in aperture so that diffraction effects confine the radiation to a beam of small divergence. Quartz electromechanical transducers are usually used for velocity measurements by guided waves in solids. Details are given of various types of quartz transducer, and equivalent circuit networks are given for the purely electrical circuit and the transformed mechanical element in a transducer. A pulse-testing method is described capable of determining transmission times to 0·01 microsec.

A. C. WHIFFIN

534.614 : 534.64

2569. Mechanical properties of polymers at ultrasonic frequencies. W. P. MASON AND H. J. MCSKIMIN. *Bell Syst. Tech. J.*, **31**, 122–71 (*Jan.*, 1952).

A number of methods are described for measuring the dispersion in the velocity and attenuation constants of the material, or a dispersion in the characteristic impedance of the material if the attenuation is too high to allow velocity measurements. They make possible propagation and impedance measurements not only in solid polymers, but also in liquid polymers and in solutions of polymer molecules in typical solvents. When these techniques are applied to long chain polymers in dilute solutions, the three relaxations observed correspond to motions occurring in isolated molecules since as the dilution increases, the molecules seldom touch. The lowest relaxation corresponds to a configurational relaxation of the molecule as a whole, the highest relaxation corresponds to the twisting of the shortest segment—containing about 40 repeating units—while the intermediate relaxation corresponds to a transient entanglement of chain segments. All three types of relaxations are present in pure polymer liquids but are spread out over a frequency range due to the perturbing effect of near neighbours of adjacent chains. The high-frequency shortest chain relaxation can be traced in solid polymers of the linear chain type such as polyethylene and Nylon and produces rubber-like response to mechanical shocks of very short duration.

A.

534.63

2570. A time constant meter for tuning forks and other high Q devices. C. T. MORROW. *J. Acoust. Soc. Amer.*, **24**, 40–1 (*Jan.*, 1952).

The time constant meter described operates on the principle that differentiation of an exponentially decaying rectified envelope decreases it in inverse proportion to the time constant and reverses its sign. Hence, it is possible to obtain a null by balancing the differentiated signal against a portion of the original. The circuit is simple, requiring only one amplifier tube and a tuning eye.

A.

534.7 : 612.85

Physiological acoustics. Hearing. *See Abstr.* 3168–73

534.773.2 : 621.395.92

2571. Selection of hearing aids. E. L. R. CORLISS. *Circ. Nat. Bur. Stand., No.* 516, 17 *pp.* (1951).

This pamphlet gives some of the basic ideas of hearing and the manner in which hearing aids reduce defects. The limitations and optimum working conditions of such aids are described and appropriate hearing tests explained. Advice is given on the choice and care of the instrument. A hearing scale, a list of U.S. hearing-aid clinics and 5 figures are shown.

R. A. WEALE (R)

534.83 : 534.321.9

2572. Some ultrasonic spectrograms produced by aeroplane and reactive engines working on the ground. P. GROGNOT AND R. LEHMANN. *Nuovo Cim.*, **7**, 377–84 (*Suppl. No.* 2, 1950) *In French.*

Hitherto, most measurements of noise of aircraft engines have been made within the audible range, but the amplitude/frequency diagrams obtained have indicated quite clearly that there must be considerable components at much higher frequencies. Diagrams have now been obtained extending up to 100 kc/s, and show that the noise contains large components in the range of ultrasonic frequencies. The paper is illustrated by numerous examples.

A. C. WHIFFIN

534.833

2573. Resonance sound absorber with yielding wall. S. N. RZHEVKIN. *Tech. Mem. Nat. Adv. Comm. Aeronaut., No.* 1273, 21 *pp.* (*May*, 1951).

This detailed analytical investigation of the effect of sympathetic vibration of a resonator front wall on sound absorption is restricted to the case of a single-sheet resonance system with compartments for normal incidence of sound. The general problem is reduced to a concise electrical analogue, which clearly illustrates all the special cases previously reported in the literature. Numerical examples are given. The front wall should be fixed sufficiently rigidly to insure that the sound-absorption coefficient is not reduced in a low-frequency absorber of this type.

APPLIED MECHANICS REVIEWS

534.833

2574. The problem of soundproofing the offices of the French administration of the P.T.T. P. CHAVASSE AND R. LEHMANN. *Ann. Télécommun.*, **6**, 381–96 (*Dec.*, 1951) *In French.*

The general problem of noise reduction and vibration elimination is considered. Results obtained in practice in a number of premises are given in detail.

The principles to be applied in carrying out sound-proofing are detailed and in an appendix the absorption coefficients of 45 acoustic materials are tabulated over the frequency range 125–6 000 c/s.

G. F. HODSMAN

534.833

2575. The theory of sound absorptive materials. C. M. HARRIS AND C. T. MOLLOY. *J. Acoust. Soc. Amer.*, **24**, 1–7 (*Jan.*, 1952).

Presents a review of the status of the theory of sound-absorbing materials. The basic concept of absorption coefficient, as well as the relation between absorption coefficient and acoustical impedance, are discussed. Other topics considered are sound propagation in homogeneous isotropic media, perforated panels, suspended absorbers and resonant absorbers. A.

534.843

2576. The analysis of the sound field in a room by the image source method. R. TAKEUCHI. *Mem. Res. Inst. Acoust. Sci. Osaka*, **2**, 34–41 (*March*, 1951).

The method is of special value when dealing with speech and music in a room. They may be of such a transient nature that the conditions in a very short time after emission may be of importance for the correct perception of the sound signal at a point. A theoretical treatment of the method is given and an example of its application to a room is outlined.

G. F. HODSMAN

534.846.6

2577. The use of ultrasonics in architectural acoustics. F. CANAC. *Nuovo Cim.*, **7**, 376 (*Suppl. No.* 2, 1950) *In French.*

A summary is given of the experimental conditions to be observed in making model experiments in architectural acoustics using ultrasound.

A. C. WHIFFIN

OPTICS . RADIATION . SPECTRA 535

535.21

2578. Mutual irradiation of a number of bodies. C. CODEGONE. *Atti Accad. Sci. Torino, I*, **85**, 3–8 (1950–51) *In Italian.*

A general treatment of the problem of calculating the effects, either thermal or photometric, produced by the mutual irradiation of a number of bodies. Several special cases are considered particularly, viz. (*a*) perfectly absorbing walls, (*b*) walls plane or convex, (*c*) imperfectly transparent medium. The solution is given for the special case of grey bodies uniformly distributed. J. W. T. WALSH

535.214.6

2579. On photophoresis, the true magnetic charge, and the helical motion of matter in [various] fields. II. F. EHRENHAFT. *Acta Phys. Austriaca*, **5**, 12–29 (*No.* 1, 1951) *In German.*

For Pt I, see Abstr. 7649 (1951). An account of the experimental data obtained to date; the effect is divided into (*a*) pure photophoresis, where it is produced by light alone, (*b*) electrophotophoresis, (*c*) magnetophotophoresis, and (*d*) gravitation photophoresis, in which cases the effect is modified by the field which is operating. It is suggested that the Brownian movement could be treated as an example of photophoresis. Much of the experimental data still requires explanation. 117 refs. N. CORCORAN

535.232

2580. The variation with wavelength of the spectral emissivity of iron and molybdenum. J. E. TAYLOR. *J. Opt. Soc. Amer.*, **42**, 33–6 (*Jan.*, 1952).

The spectral emissivity of Fe and Mo has been investigated as a function of wavelength in the visible spectrum. A gradual rise in the emissivity for both metals was observed as the blue end of the spectrum is approached. The increase in the emissivity of Fe with decrease in wavelength is much greater than that observed for Mo. The emissivity of Fe in the body-centred form at temperatures below 1 178°K is observed to be higher at all wavelengths than it is for the higher temperature face-centred cubic form. A.

535.232

2581. The spectral emissivity of iron-nickel alloys. H. B. WAHLIN, R. ZENTNER AND J. MARTIN. *J. Appl. Phys.*, **23**, 107–8 (*Jan.*, 1952).

The spectral emissivity for $\lambda = 6\,700$ Å has been determined for Fe–Ni alloys and shows changes with temperature which indicate that in the temperature range of 1 200°K to 1 600°K abnormal behaviours exist which hitherto have not been suspected. A correlation of emissivity change with change in density of metals is suggested. A.

535.245

2582. Illumination produced by linear sources. C. CODEGONE. *Atti Accad. Sci. Torino, I*, **85**, 297–300 (1950–51) *In Italian.*

Gives a method for calculating the illumination from line sources, whether rectilinear or in the form of certain planar curves. J. W. T. WALSH

535.245

2583. Illumination from radiating surfaces. G. BETHE. *Optik*, **8**, 476–87 (*No.* 10); 489–511 (*No.* 11, 1951) *In German.*

A fundamental treatment of the subject leading to expressions for the illumination from a number of surface sources of practical importance. These include surfaces of triangular, rectangular and linear forms, parallelograms, trapezoids, elliptical and circular disks. Certain special cases are developed so as to lead to formulae convenient for calculation and the illumination curves for a plane illuminated by these sources are given. There is a short section on volume sources. J. W. T. WALSH

535.245

2584. Methods of calculating the light distribution of mirrors at an arbitrary cross-section. H.-J. HENTSCHEL. *Optik*, **8**, 517–32 (*No.* 11, 1951) *In German.*

The light distribution at any point in the beam from a mirror used as a condenser, is found by numerical integration or by a planimeter. An example using a parabolic mirror is given and the calculations compared with the intensity found experimentally. R. W. FISH

535.247.1 : 778.392 : 518.3

2585. A nomogram for photographic spectrophotometry. J. NOAR. *Photogr. J. B*, **91**, 99–101 (*Sept.–Oct.*, 1951).

A nomographic method is described which simplifies the treatment of photographic data for spectrophotometry. Separate nomograms are needed for each set of emulsion response parameters, and a chart is described which facilitates nomogram construction from a few calibration data. A.

535.247.4 : 545.82

Internal standard flame photometry. *See Abstr.* 3095

535.313 : 534.24

Equi-reflecting surfaces. *See Abstr.* 2538

535.317

2586. Certain symmetrical pancratic systems of three lenses. A. BIOT. *Ann. Soc. Sci. Brux.* (*Sér.* 1) **65**, 116–24 (*No.* 2–3, 1951) *In French.*

The systems studied consist of two positive lenses of equal power symmetrically placed around a negative lens, the whole system giving an image at -1 magnification of a real object. The object and the negative lens are kept fixed, and the two positive lenses are moved together, to give a variable magnification and a change of image plane. Equations are derived for these effects, and tables given to simplify numerical calculation. R. W. FISH

535.317.4

2587. A note on the calculation of principal ray aberration. R. S. LONGHURST. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 116–17 (*Feb.*, 1952).

An expression for the spherical aberration of the principal rays is derived. If the primary aberrations are calculated the principal ray aberration may be found with very little additional effort. A.

535.317.5

2588. The calculation of Seidel coefficients: comparison with the aberration values of von Rohr and with the reduced aberrations. H. SLEVOGT. *Optik*, **8**, 537–42 (*No.* 12, 1951) *In German.*

Formulae are given for the derivation of the geometric aberration terms of the von Rohr notation from the Seidel coefficients. The reduced aberration coefficients are obtained after allowing for the resolving power of the system. R. W. FISH

535.317.9

2589. Error balancing in fast Schmidt cameras. E. H. LINFOOT. *Mon. Not. Roy. Astron. Soc.*, **111**, 75–93 (*No.* 1, 1951).

535.321

2590. An interferometric method of studying local variations in the refractive indices of a solid. R. C. FAUST. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 48–62 (*Jan.*, 1952).

Many small transparent solids possess local variations in their refractive indices that cannot be detected by the standard immersion methods. This difficulty has been overcome by placing the immersed solid between the two parallel, metal-coated plates of an interferometer illuminated at normal incidence by a parallel beam of white light. The immersion liquid is so chosen that its dispersion curve intersects that of the solid at some wavelength within the visible spectrum. An image of the immersed specimen is then projected on to the slit of a spectrometer, whereupon one can observe coloured fringes of equal chromatic order (channelled spectra). These fringes generally suffer a displacement on crossing from the liquid to the liquid-solid region of the interferometer; this displacement does, however, vanish at that wavelength at which the refractive index of the liquid equals that of the solid. The method is equally applicable to both isotropic and birefringent specimens, the index measurements under favourable conditions being accurate to within $\pm 0{\cdot}0001$. Particular reference is made to the possibility of studying the skin effect in rayon fibres. A.

535.321 : 536.48

2591. Refraction of solids. Measurements at low temperatures. M. BARBARON. *Ann. Phys.* [*Paris*] **6**, 899–959 (*Nov.–Dec.*, 1951) *In French.*

The factors upon which the refractive index of a transparent solid depend are discussed and the validity of the Lorentz–Lorenz equation examined. A new parameter, called the specific dispersion, which is a function of $dn/d\lambda$, is established and its application explained. Subtraction of the principal specific refractions $[(n^2 + 1)/(n^2 + 2)\rho$, where n = refractive index, ρ = density] gives the specific birefraction, the details and use of which are given. The thermal variation of the specific refraction, absolute indices of refraction, birefringence and dispersion for sodium chloride, fluorine, ammonium chloride, ammonium bromide, zinc blende, Plexiglass, quartz and calcite have been measured down to -200°c by the use of a prism goniometer, full details of which are given. The results of the measurements are fully discussed. H. G. JERRARD

535.323–15 : 535.343–15

2592. Optical properties of tellurium in the infrared. T. S. MOSS. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 62–6 (*Jan.*, 1952).

The refractive index and absorption constant of Te layers have been measured in the near infrared. The refractive index has been measured over the wavelength range 3 μ to 11 μ. The value extrapolated to long wavelengths is found to be $4{\cdot}8$; this is much higher than any other known refractive index. Absorption measurements were made for wavelengths 1 μ to 3 μ: the absorption constant is $2{\cdot}2 \times 10^5$ cm^{-1} at $1{\cdot}0$ μ, falling rapidly with increasing wavelength. Transmission measurements on bulk specimens are possible at wavelengths greater than $3{\cdot}3$ μ. A.

535.33–15

2593. Infrared spectrometry since 1945. V. Z. WILLIAMS. *Appl. Spectroscopy*, **6**, 14–20 (*Nov.*, 1951).

A review of technique and instruments (52 refs).

535.33.07

2594. A high vacuum recording spectrograph for the study of radiation from solids in the 100–800 Å range. E. R. PIORE, G. G. HARVEY, E. M. GYORGY AND R. H. KINGSTON. *Rev. Sci. Instrum.*, **23**, 8–12 (*Jan.*, 1952).

The two-meter grazing-incidence vacuum spectrograph used by O'Bryan and Skinner for the study of

the emission bands of solids has been rebuilt to operate with improved sensitivity and speed. The major modification is the replacement of the photographic plate by a Be–Cu photomultiplier which is designed to traverse the Rowland circle, giving a continuous record of photon-counting rate as a function of a wavelength. With the photomultiplier it is possible to take as many separate curves as desired, subject to X-ray target condition, without opening the spectrograph, which is normally evacuated to better than 10^{-5} mm Hg. In addition, the sensitivity is increased about a thousandfold; i.e. with a photographic plate, the target current and voltage needed are 10–100 mA and about 3 000 V for a one- to three-hour exposure. Using the photomultiplier, however, these values may be reduced to 2–3 mA and 300–500 V, respectively, and the complete emission band may be recorded in 5 min. The results for Al are in excellent agreement with the results of previous authors. A.

535.33.07

2595. Notes on the design, adjustment and calibration of spectrophotometers. C. W. B. Normand and R. H. Kay. *J. Sci. Instrum.*, **29**, 33–9 (*Feb.*, 1952).

Techniques of calibration and adjustment of spectrophotometers, made possible by the high sensitivity of photomultipliers, together with some general principles of design, are illustrated with reference to the Dobson spectrophotometer for measurements in the near ultra-violet. This instrument is primarily intended to investigate atmospheric ozone, but the methods described are of general application. Techniques discussed include (1) the use of null-balancing to measure intensity ratio of nearby wavebands, whose variance, both in the instrumental measurement and in the light source itself, is less than that of direct intensity recording; (2) the use of synchronous commutator rectification of the chopped light signals to discriminate against random fluctuations, giving a centre-zero deflection linear with intensity; (3) new methods of optical alignment to ensure that the maximum possible aperture is used but that the effective stops act on undispersed light only, giving all wavelengths of the same incident beam an equal chance to pass to the exit slit; (4) determination of photomultiplier characteristics and methods of setting to obtain repeatable outputs; (5) an accurate null-method for calibration of the optical wedge. Eighteen Dobson spectrophotometers have to date (January 1951) been adjusted, calibrated and inter-compared for an international programme for the world-wide study of atmospheric ozone. All adjustment and calibration must be very closely controlled if, as here, two or more spectrophotometers are to give identical readings when observing identical light sources. Observations with the instrument on direct sunlight and moonlight and on sunlight scattered from the zenith sky are illustrated. A.

535.33.07–15

2596. The astigmatism of a multiple path absorption cell. T. R. Reesor. Letter in *J. Opt. Soc. Amer.*, **41**, 1059–60 (*Dec.*, 1951).

The optical system of a multiple path absorption cell for use with a Perkin–Elmer infrared spectrometer is described. Good agreement between measured and calculated values of the astigmatism up to 32 traversals of the light beam is obtained.

W. R. ANGUS

535.33.07–15

2597. A universal slit drive mechanism for single beam infra-red spectrometers. C. G. Cannon. *J. Sci. Instrum.*, **34**, 49–52 (*Feb.*, 1952).

A simple exponential drive mechanism is described which can be used with any prism (e.g. lithium fluoride, rocksalt, potassium bromide, etc.) or grating without alteration, to control the slit programme required to produce an approximately constant energy background. The control mechanism can be adjusted for various ranges of slit width settings so that any resolving power within the limits of the spectrometer may be obtained. A.

535.331

2598. Analysis of the excitation characteristics of spectra emitted by ferrous alloys. J. K. Hurwitz and J. Convey. *J. Opt. Soc. Amer.*, **42**, 24–31 (*Jan.*, 1952).

The excitation potentials of the observed wavelengths of the spectral lines emitted in the low alloy steel spectrum were calculated. Tentative homologous line pairs were selected on the basis of similar excitation potentials and freedom from interferences. The slopes of the working curves were found to be independent of alloying elements, matrix and discharge conditions. Alterations in the circuit parameters and consequent changes in the discharge had little or no influence upon the intercept of the working curves. Self-reversal of either or both of the alloying element line and the internal standard line was observed. The self-reversal was removed by selecting spectral lines of higher excitation potentials or directing an air blast across the discharge. In this way, the working curves were linear over all concentrations considered. Element interference correction factors, which were found to be functions of the concentration of the interfering element, could be applied to data so that one working curve could be used regardless of the major alloying constituents in the sample. Reproducibility tests indicate some improvement in accuracy when the air blast was employed. A.

535.331 : 539.153.4

***L*(*L* + *l*) correction to the spectra of the iron group.** *See Abstr.* 2924

535.338.3

2599. Energy levels and wavelengths of the isotopes of mercury 198 and 202. K. Burns and K. B. Adams. *J. Opt. Soc. Amer.*, **42**, 56–9 (*Jan.*, 1952).

In the region 6 709–2 302 Å the wavelengths of 60 lines in the first spectra of the even isotopes of Hg, Hg^{198} and Hg^{202}, have been measured relative to 5 460·7532 Å. Electrodeless tubes containing 0·5 mg of Hg were excited by radiowaves of 90 to 300 Mc/s frequency. Comparison with the data of Meggers and Kessler shows the median difference AOW − MK to be 0·0001 Å. A comparison of the wavelength and level systems of the two isotopes confirms the opinion that the spectrum of natural Hg may be useful as a source of secondary standards, since the isotope shift of the odd level $6p^1P_1^\circ$ is nearly the same as that of several even levels. A.

535.338.3 : 535.343.4–15

2600. Precise measurements in the infrared spectrum of carbon monoxide. E. K. Plyler, W. S. Benedict and S. Silverman. *J. Chem. Phys.*, **20**, 175–84 (*Jan.*, 1952).

New measurements have been made in the CO infrared spectrum in both emission and absorption, using a 15 000-line/inch grating spectrograph and a 7 200-line/inch vacuum grating spectrograph. High precision in wavelength determinations was obtained by superimposing on the spectra emission lines in higher order of Hg, Kr and A discharges. The measurements are believed accurate to $\pm 0{\cdot}02\ cm^{-1}$. The observed lines in absorption are those of the 2–0 and 3–0 bands of $C^{12}O^{16}$, between $R\,30$–$P\,29$ and $R\,9$–$P\,16$, respectively; 27 lines of $C^{13}O^{16}$ and 10 lines of $C^{12}O^{18}$ have also been measured. In emission from oxy-acetylene and CO–O_2 flames, over 300 lines in the 2–0, 3–1, 4–2 and 5–3 bands have been identified between 4 360 and 4 000 cm^{-1}. The emission bands form heads in the R branch near $J = 50$, and the 2–0 band shows resolved lines out to $J = 46$ in both P and R branches. The new measurements are in good agreement with earlier results at low quantum numbers, but show discrepancies at high numbers which result in slightly different values for the molecular constants, especially in y_e and D_e. The observed isotope shifts of the 2–0 band origin for C^{12}–C^{13} and O^{16}–O^{18} are, respectively, $93{\cdot}27 \pm 0{\cdot}02\ cm^{-1}$ and $101{\cdot}03 \pm 0{\cdot}05\ cm^{-1}$, in good agreement with the calculated values. The emission spectra permit the determination of rotational "temperatures" with an accuracy of $\pm 5\%$ and vibrational "temperatures" with an accuracy of $\pm 10\%$. Thermal equilibrium between the two modes is observed in the outer cone of the flames, but in the region just above the reaction zone, the rotational temperatures are several hundred degrees higher than the vibrational values or the calculated equilibrium values. A.

535.338.4

2601. The molecular spectrum of iodine excited in the presence of an inert gas. K. Wieland and J. Waser. Letter in *Phys. Rev.*, **85**, 385–6 (*Jan.* 15, 1952).

Revised constants for the $D \leftrightarrow X$ and $F \rightarrow X$ systems ($\nu_e = 33\,346{\cdot}6$ and $47\,208{\cdot}25\ cm^{-1}$ respectively) are given on the basis of the new expression for G_v'' [Abstr. 442 (1952)]. The new vibrational analyses differ, especially for the D–X system, from those given by Venkateswarlu [Abstr. 4265 (1951)]. It is not certain that the system called C–X has in fact X as its lower state. R. F. Barrow

535.338.4

2602. The excitation and intensity distribution of CH bands in flames. R. A. Durie. *Proc. Phys. Soc. [Lond.] A*, **65**, 125–8 (*Feb.*, 1952).

An apparent selective excitation to the $v' = 1$ level of the CH 3 900 Å ($^2\Sigma^- \rightarrow {}^2\Pi$) system occurs in hydrogen flames containing small amounts of organic compounds since the (1, 0) and (1, 1) bands are abnormally strong. This is accompanied by a suppression of the usual predissociation in this system. An additional band of this system, the (1, 2) at 4 494·5 Å, has been observed for the first time. The suppression of the CH predissociation is interpreted as showing that conditions in hydrogen flames approach thermal equilibrium. The appearance of the CH predissociation in normal flames indicates that the excitation is not thermal. A.

535.338.4

2603. The spectra of flames supported by fluorine. R. A. Durie. *Proc. Roy. Soc. A*, **211**, 110–21 (*Feb.* 7, 1952).

I. Flames with organic substances: F reacts with most organic substances, the reaction being accompanied by a flame. The spectra of several of these flames are described. The hydrocarbon–F flames emit C_2 and CH bands. The organic halide/F flames emit a yellow-green continuum, but the gradual addition of H causes first heavy C formation, which then decreases as C_2 bands, then CH begin to appear until, finally, only C_2 and CH bands are emitted. The 4 050 Å comet-head group of bands appear in these flames under conditions giving C formation and strong C_2 and weak CH. The similarity of the spectra of the hydrocarbon–F and hydrocarbon–O flames and the possible mechanisms for C and C_2 and CH formation in these flames are discussed. The possible identity of the emitter of the 4 050 Å comet-head group is discussed.

II. Flames with inorganic substances: The reactions of F with many inorganic substances are accompanied by flames. The spectra of the F-supported flames with H, S, water and ammonia have been studied. S is a persistent impurity in the H flame which proves to be a good source for the SH (0, 0) emission band. The water flame emits the O Schumann–Runge bands with unusual appearance due to a low rotational temperature; the vibrational intensity distribution of the Schumann–Runge bands in this source has been studied and is found to agree quite well with the theoretically predicted distribution. The ammonia flame emits new bands in addition to the NH (0, 0) band at 3 360 Å; these bands are identical with those observed in H azide explosions and their assignment to the NH radical is thus supported. A.

535.338.42

2604. The rotational analysis of the (0, 0) and (0, 1) bands of the $^7\Pi \rightarrow {}^7\Sigma$ system of manganese deuteride. T. E. Nevin, M. Conway and M. Cranley. *Proc. Phys. Soc. [Lond.] A*, **65**, 115–24 (*Feb.*, 1952).

The band spectrum of manganese deuteride has been photographed at a dispersion of 1·25 Å/mm. The heads of the (0, 0) and (0, 1) bands of the $^7\Pi \rightarrow {}^7\Sigma$ system are at $\lambda 5703{\cdot}7$ Å and $\lambda 6073{\cdot}3$ Å respectively. It has been possible to make a rotational analysis of the two bands. The constants of the final state have been derived from the analysis and the fine structure resulting from the interaction of spin and rotation has been studied. The $^7\Pi$ state is perturbed and the terms have been evaluated from the term expressions for the final state and the wave numbers of the P, Q and R branches. The results throughout are in good agreement with the results for the corresponding bands in the spectrum of manganese hydride. A.

535.343 : 541.14 : 541.126

Spectroscopic studies of the hydrogen-oxygen explosion initiated by flash photolysis of nitrogen dioxide. *See Abstr.* 3062

535.343.2/.4–15

2605. On the infrared spectrum of hydrazine. P. A. Giguère and I. D. Liu. *J. Chem. Phys.*, **20**, 136–40 (*Jan.*, 1952).

The absorption spectrum of hydrazine was re-examined in the region 1·5–25 μ with a prism instrument. In the vapour some 20 bands were found of which a few are appreciably different from previous data. The low-frequency fundamentals showed enough structural details to make possible a rough calculation of the rotational constants of the molecule. Because of extensive overlapping the identification and assignment of certain bands remain doubtful. The absorption spectrum of the liquid and that of the solid at −70° were also measured over a limited range. A.

535.343.2/.4–15

2606. The infrared spectra of naphthalene crystals, vapor, and solutions. G. C. Pimentel and A. L. McClellan. *J. Chem. Phys.*, **20**, 270–7 (*Feb.*, 1952).

The infrared spectra of naphthalene in the gas phase, in solutions of carbon tetrachloride, carbon disulphide and methyl cyclopentane, and as single crystals have been obtained in the region 3 300–450 cm^{-1}. The dichroism of three different single crystal planes, including the cleavage plane, has been studied using polarized infrared radiation. The frequencies were segregated into their respective symmetry classes on the basis of an assumed oriented gas model. Band contour data, together with a statistical comparison of the spectrum of the gas phase with the spectra of the condensed phases establish the usefulness of this model. A.

535.343.2/.4–15 : 535.375.5

2607. Internal rotation in ethylene chlorhydrin. S. Mizushima, T. Shimanouchi, T. Miyazawa, K. Abe and M. Yasumi. *J. Chem. Phys.*, **19**, 1477–9 (*Dec.*, 1951).

The Raman and the infrared spectra of ethylene chlorhydrin have been remeasured with results which show that the molecules take both the *trans* and the *gauche* forms in the gaseous and the liquid states, while they take only the *gauche* form in the solid state. By the measurement of the temperature dependence of the infrared absorption the energy difference between these two forms has been found to be 0·95 kcal/mol. A.

535.343.2

2608. Study of X-ray induced optical absorption bands in CaF_2. S. Barile. *J. Chem. Phys.*, **20**, 297–301 (*Feb.*, 1952).

The absorption spectrum of CaF_2 crystals containing colour centres was investigated as a function of temperature and time elapsed after having been irradiated with X-rays under various conditions. A weak absorption band previously unobserved has been found near 2 280 Å. The intensities of the four absorption bands of crystals irradiated at room temperature decreased to the same extent after having been heated at various temperatures for various time intervals. Irradiation with light at room temperature does not cause any appreciable bleaching. At elevated temperatures the bleaching rate is increased by light. The colour of the absorbed light does not, however, produce any preferential bleaching of any one of the bands. The type of decay and the energies involved were calculated from results obtained by bleaching the crystals at several temperatures. In view of these facts, it would seem that the bands are due to either one type of centre, or else to several types incapable of existing independently. The results of the computation of the number of colour centres responsible for 3 of the bands are not incompatible with this point of view. A.

535.343.2 : 535.371 : 535.515

2609. Optical properties of counting diamonds. R. K. Willardson and G. C. Danielson. *J. Opt. Soc. Amer.*, **42**, 42–9 (*Jan.*, 1952).

Some optical properties of 32 γ-counting diamonds have been investigated. These properties include the u.v. transmission limit, the i.r. absorption spectra, the birefringence and the luminescence. The approximate percentage of Type I and Type II, estimated by both the u.v. and i.r. absorption criteria, and the relative counting efficiency of each diamond are shown together on a single chart. One concludes that good γ-counting diamonds usually have substantial portions that are Type II, but diamonds entirely Type II are not necessarily good counters. In addition to the well-known absorption maximum at a wavelength of 8 microns, Type I diamonds appear to exhibit an absorption maximum at a wavelength of 21 microns. Experimental evidence is given for the existence of normally empty trapping levels 0·5 eV and 0·7 eV below the conduction band and for the existence of point contact rectification in diamond. A.

535.343.2 : 539.11

2610. The structure of the long wave absorption edge of insulating crystals. I. C. Cheeseman. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 25–32 (*Jan.*, 1952).

A general process, by which light can be absorbed in insulators at frequencies less than the frequency corresponding to the energy gap, is considered. Using an Einstein model with a constant energy gap, calculation of such a process is made by means of the method of intermediate states. The results are tested for the case of cadmium sulphide, and agreement with experimental results is found to be good when allowance is made for mathematical approximations made in the calculations. A.

535.343.2–15

2611. Infrared spectra of rapidly solidified vapors. F. E. Malherbe and H. J. Bernstein. Letter in *J. Chem. Phys.*, **19**, 1607–8 (*Dec.*, 1951).

The infrared spectrum of rapidly solidified 1, 2-dichloroethane vapour at 94°K is similar to that of the liquid with bands resulting from both the *gauche*- and *trans*-isomers. The *gauche*-bands disappear completely at about 123°K, indicating crystallization of the original glassy solid. A small temperature-reversible frequency shift also occurs at approx. 173°K. W. R. ANGUS

535.343.2–15

2612. Infrared spectrum of some complex hexafluorides. A. DE LATTRE. Letter in *J. Chem. Phys.*, **19**, 1610 (*Dec.*, 1951).

The infrared spectra of synthetic cryolite, Na and NH_4 fluoferriates, and KPF_6 have been studied.

W. R. ANGUS

535.343.2–15 : 539.11

2613. Infra-red spectra and the solid state. III. Potassium bifluoride. G. L. COTÉ AND H. W. THOMPSON. *Proc. Roy. Soc. A*, **210**, 206–16 (*Dec.* 20, 1951).

For Pt II, see Abstr. 952 (1949). The infrared spectrum of KF_2 has been determined between 2 and 8 μ at temperatures between 293 and 90°K. On passing from room temperature to that of liquid air, some of the absorption bands sharpen and split. The results have been analysed with the object of assigning fundamental vibration frequencies to the $(HF_2)^-$ ion, and also of deciding whether this ion has a symmetrical or unsymmetrical structure. Values assigned to the stretching vibration frequencies are 600 and 1 450 cm^{-1}, and to the deformation a pair at 1 225/1 274 cm^{-1}. The spectrum can then be satisfactorily explained in terms of the selection rules which would be expected for a symmetrical $(HF_2)^-$ ion lying in the particular crystal field suggested by X-ray work. Whereas the bending vibrations appear to involve little anharmonic character, there is an apparently large negative anharmonic coefficient for the overtone and combinations of the stretching vibration frequencies. This might be expected if the potential energy function for the antisymmetrical stretching vibration involved a higher power of the displacement co-ordinate than the second, and strengthens the interpretation in terms of a symmetrical ion. The molecular environment of the ion in the crystal state leads to a removal of the degeneracy of the deformational vibration, the latter being found to split, although one component is not noticed in absorption when the crystal is viewed along the *c*-axis.

A.

535.343.2–15 : 539.11

2614. Infra-red spectra and the solid state. IV. Borofluorides. G. L. COTÉ AND H. W. THOMPSON. *Proc. Roy. Soc. A*, **210**, 217–23 (*Dec.* 20, 1951).

The vibrational spectra of the solid crystalline borofluorides of NH_4, K and Na have been measured between 2 and 25 μ, both at room temperatures and at that of liquid air. The bands observed have been assigned to vibrational frequencies of the $(BF_4)^-$ and $(NH_4)^+$ ions. Some of the bands are found to split into two or more components, and this splitting has been considered in terms of isotopic species and in relation to the removal of vibrational degeneracy which may arise when the tetrahedral ions are situated in a crystal field of lower symmetry.

A.

535.343.32

2615. An investigation of certain solvent effect in absorption spectra. A. L. LEROSEN AND C. E. REID. *J. Chem. Phys.*, **20**, 233–6 (*Feb.*, 1952).

A study of the solvent effects in the spectra of non-ionic compounds to whose structure a zwitter ion form makes appreciable contribution (particularly in the excited state) has revealed 3 distinct effects: (1) A shift of absorption bands to greater wavelength with increasing refractive index, as predicted by Kundt's rule. This is ascribed to the effect of electronic polarizability on the zwitter ion structure, and is seen unmixed with the other effects only when the solvents are hydrocarbons or aryl halides. (2) A further shift which appears with most solvents other than hydrocarbons and aryl halides, and is ascribed to orientation of molecules of non-uniform polarizability. (3) The Kuhn–Brockmann effect—a large shift which appears whenever hydrogen bonds between the solvent and solute occur. This is believed to be due to the stabilization of the zwitter ion by the electrostatic nature of the H bond. No correlations of the spectra of phenolphthalein, *p*-rosaniline hydrochloride, or iodine with the properties of the solvent were found.

A.

535.343.32–15

2616. The NH stretching vibration and NH–N hydrogen bonding in several aromatic compounds. N. FUSON, M.-L. JOSIEN, R. L. POWELL AND E. UTTERBACK. *J. Chem. Phys.*, **20**, 145–52 (*Jan.*, 1952).

The three-micron infrared absorption bands assigned to the NH stretching vibration have been studied in pyrrole, indole, carbazole, diphenylamine and aniline. Spectra have been obtained in solution in carbon tetrachloride, carbon disulphide, chloroform and benzene over a wide range of concentrations. In pyrrole and indole with increasing concentration the sharp NH band fades out and a broader band to lower frequencies appears. While the results are not as clearcut for diphenylamine and aniline, for these four compounds hydrogen bonding satisfactorily explains the observed data. This conclusion, for pyrrole and indole, sets aside the infrared spectroscopic basis for Pauling's hypothesis of two species of molecules. Carbazole was not soluble enough to make association studies possible. The relation of both the solvent and the solute molecular structure to the position of the associated and unassociated frequencies is discussed.

A.

535.343.32–32

2617. Far u.v. spectra of peptides. J. S. HAM AND J. R. PLATT. *J. Chem. Phys.*, **20**, 335–6 (*Feb.*, 1952).

The spectra of diglycyl, triglycyl and glycine anhydride have been extended to 1 800 Å in water solution. The peak observed near 1 850 Å is attributed to an almost additive absorption by the —CONH— groups. The oscillator strength f is $0{\cdot}27 \pm 0{\cdot}07$ per peptide group.

A.

535.343.4

2618. Experimental determination of absolute *f*-values for methane. L. GOLDBERG, O. C. MOHLER AND R. E. DONOVAN. *J. Opt. Soc. Amer.*, **42**, 1–6 (*Jan.*, 1952).

The absolute *f*-values of rotational lines in the positive and negative branches of the $2\nu_3$ overtone band of CH_4 have been derived from absorption measurements in the laboratory by two independent methods. The first method involves the use of the curve of growth and requires the observation of weak lines for which the total absorption is independent of the damping constant. In the second method the lines

are broadened artificially, by the introduction of about 3 atmos. of air, to half-widths that are about five times the slit width. The *f*-values are then determined by integration of the logarithm of the percentage absorption over the line profile. On the average, the *f*-values obtained by the two methods agree within 10%. A.

535.343.4

2619. Absorption spectrum of free NH_2 radicals. G. HERZBERG AND D. A. RAMSAY. Letter in *J. Chem. Phys.*, **20**, 347 (*Feb.*, 1952).

The absorption spectrum of the product(s) of photolysis of NH_3 shows 50 absorption lines in the region 5 700–6 900 Å which correspond to those of the emission spectrum of NH_3–O_2 or H_2–N_2O flames. G. F. LOTHIAN

535.343.4–14

2620. Line breadths in the 5-mm microwave absorption of oxygen. B. V. GOKHALE AND M. W. P. STRANDBERG. Letter in *Phys. Rev.*, **84**, 844 (*Nov.* 15, 1951).

The measurements were made to try to reconcile earlier reports [Abstr. 202, 4248 (1951)]. The apparatus used is described and the results are given with their probable errors. A. J. TAYLOR

535.343.4–14

2621. The microwave spectrum of furan. M. H. SIRVETZ. Letter in *J. Chem. Phys.*, **19**, 1609–10 (*Dec.*, 1951).

Transition assignments of 26 strong absorption frequencies of furan in the microwave *K*-band have been made. A planar molecule of near oblate symmetry is indicated by the derived rotational constants. W. R. ANGUS

535.343.4–14

2622. The microwave spectra of the deuterated methyl halides. J. W. SIMMONS AND J. H. GOLDSTEIN. *J. Chem. Phys.*, **20**, 122–3 (*Jan.*, 1952).

The hyperfine structure lines of the pure rotational absorption transitions $J = 0 \rightarrow 1$ for CD_3Cl and $J = 1 \rightarrow 2$ for CD_3Br and CD_3I, all in the ground vibrational state, have been measured in frequency and yield the following values of ν_0 in Mc/s and I_B in g cm$^2 \times 10^{-40}$, respectively: for CD_3Cl^{35}, 21 683·75 and 77·3764; for CD_3Cl^{37}, 21 316·86 and 78·7081; for CD_3Br^{79}, 30 858·29 and 108·743; for CD_3Br^{81}, 30 724·93 and 109·215; for CD_3I, 24 161·13 and 138·885. The quadrupole coupling coefficient, eqQ, has been determined for each of these molecules and its variation from eqQ for the corresponding normal methyl halide compound is considered. A.

535.343.4–14 : 539.133

2623. The microwave spectrum of a slightly aspherical top—the structure and dipole moment of sulfuryl fluoride. R. M. FRISTROM. *J. Chem. Phys.*, **20**, 1–5 (*Jan.*, 1951).

The microwave spectrum of the slightly aspherical rotor, sulphuryl fluoride, has been investigated. Seven lines were found in the 20–30 000 Mc/s region. Six of these lines were assigned to $J = 1 \rightarrow 2$ and $2 \rightarrow 3$ rotational transitions of the molecule $S^{32}O_2F_2$ and the other to the $1_{11} \rightarrow 2_{12}$ transition of $S^{34}O_2F_2$. These lines can be fitted to within the limits of experimental error (0·002%) with reciprocal moments of inertia, from which, assuming C_{2v} symmetry, structural parameters were determined. The S–O distance differs by −0·06 Å from the published electron diffraction value. Measurements on Stark lobes of the three $1 \rightarrow 2$ transitions of $S^{32}O_2F_2$ gave a quantitative check of the assignment and a value of 0·228 Debye units for the dipole moment. A.

535.343.4–14 : 539.133

2624. Microwave spectra and molecular structures of POF_3, PSF_3, $POCl_3$, and $PSCl_3$. Q. WILLIAMS, J. SHERIDAN AND W. GORDY. *J. Chem. Phys.*, **20**, 164–7 (*Jan.*, 1952).

From measurements of pure rotational transitions in the microwave region the following B_0 values in Mc/s were determined: 4 594·25 ± 0·04 for $PO^{16}F_3$, 4 395·27 ± 0·20 for $PO^{18}F_3$, 2 657·63 ± 0·04 for $PS^{32}F_3$, 2 614·73 ± 0·04 for $PS^{33}F_3$, 2 579·77 ± 0·04 for $PS^{34}F_3$, 2 015·20 ± 0·05 for $PO^{16}Cl_3^{35}$, 1 932·38 ± 0·08 for $PO^{16}Cl_3^{37}$, 1 402·64 ± 0·05 for $PS^{32}Cl_2^{35}$, 1 355·72 ± 0·05 for $PS^{32}Cl_3^{37}$, 1 370·13 ± 0·05 for $PS^{34}Cl_3^{35}$. With the aid of electron diffraction results the molecular structures have been determined as follows: for POF_3, $d_{PO} = 1·45 \pm 0·03$ Å, $d_{PF} = 1·52 \pm 0·02$ Å and $\angle FPF = 102·5° \pm 2°$; for PSF_3, $d_{PS} = 1·87 \pm 0·03$ Å, $d_{PF} = 1·53 \pm 0·02$ Å and $\angle FPF = 100·3° \pm 2°$; for $POCl_3$, $d_{PO} = 1·45 \pm 0·03$ Å, $d_{PCl} = 1·99 \pm 0·02$ Å and $\angle ClPCl = 103·6° \pm 2°$. The structure of $PSCl_3$, determined entirely from microwave data, is: $d_{PS} = 1·85 \pm 0·02$, $d_{PCl} = 2·02 \pm 0·01$ and $\angle ClPCl = 100·5° \pm 1°$. A.

535.343.4–14 : 539.133

2625. Microwave spectrum and structure of ReO_3Cl. E. AMBLE, S. L. MILLER, A. L. SCHAWLOW AND C. H. TOWNES. Letter in *J. Chem. Phys.*, **20**, 192–3 (*Jan.*, 1952).

Various lines from 12 000 to 51 000 Mc/s give the structure as a symmetrical top with Re–Cl 2·230 ± 0·004 Å, Re–O 1·761 ± 0·003 Å and Cl–Re–O angle 108° 20′ ± 1°; the quadrupole coupling constant, $|eqQ| \simeq 800$ Mc/s. D. H. WHIFFEN

535.343.4–15

2626. Rotation-vibration spectra of diatomic and simple polyatomic molecules with long absorbing paths. VII. The spectrum of dideuteroacetylene (C_2D_2) in the photographic infrared. B. D. SAKSENA. *J. Chem. Phys.*, **20**, 95–101 (*Jan.*, 1952).

Twelve absorption bands of C_2D_2 have been observed in the photographic infrared. Eleven of these bands show simple *P* and *R* branches with intensity alternation, i.e. they are Σ_u^+–Σ_g^+ bands, while one band, without intensity alternation, is a difference band of type II–II. From the positions of the bands some of the vibrational constants ω_i^0 and x_{ik} are determined. In addition, from the rotational fine structure, the rotational constants $B_{[v]}$ and $D_{[v]}$ are determined. For $B_{[0]}$ the value $0·8478_7$ cm^{-1} is obtained. The α_i values are $\alpha_1 = +0·0057_8$, $\alpha_2 = +0·0030_2$, $\alpha_3 = +0·0045_5$, $\alpha_4 = -0·0012_0$, $\alpha_5 = -0·0026$ cm^{-1}. From the α_i and $B_{[0]}$ one obtains $B_e = 0·8507_5$ cm^{-1}. Combining $B_e(C_2D_2)$ with $B_e(C_2H_2)$ yields, for the internuclear distances in the acetylene molecule, $r_e(C{\equiv}C) = 1·201_0 \times 10^{-8}$

and $r_e(C-H) = 1{\cdot}063_7 \times 10^{-8}$ cm in very satisfactory agreement with the values previously obtained from $B_e(C_2HD)$ and $B_e(C_2H_2)$. Evidence for *l*-type doubling in C_2D_2 is given and approximate values for the *l*-type doubling constants q_4 and q_5 are obtained. [For Pt VI, see Abstr. 2548 (1951)]. A.

535.343.4–15

2627. The infrared spectra of CF_4 and GeF_4. P. J. H. Woltz and A. H. Nielsen. *J. Chem. Phys.*, **20**, 307–12 (*Feb.*, 1952).

The i.r. spectrum of CF_4 has been remeasured from 2–19 μ and extended to about 33 μ, and the i.r. spectrum of GeF_4 has been observed from 2–38 μ. Through the use of purer samples and more gas than in previous investigations, a large number of new overtones and combination bands were observed in CF_4, and several bands were eliminated as impurities. Identifications of these bands are given. The infrared-inactive ν_2 was observed, probably because of interaction with ν_4, at 435 cm^{-1} in agreement with the Raman line at 437 cm^{-1}. In GeF_4 the two active fundamentals ν_3 and ν_4 were observed at 800 cm^{-1} and 260 cm^{-1}, respectively. Eight overtone and combination bands were discovered. From these the values of ν_1 and ν_2 were calculated to be 740 cm^{-1} and 200 cm^{-1}, respectively. Compared with the fundamentals of $GeCl_4$ and $GeBr_4$, these frequencies seem reasonable. The most striking feature of the spectrum of GeF_4 is the scarcity of bands as compared with both CF_4 and SiF_4. A.

535.343.4–15 : 535.375.5

2628. The spectra of bromine pentafluoride. T. G. Burke and E. A. Jones. Letter in *J. Chem. Phys.*, **19**, 1611 (*Dec.*, 1951).

The positions and relative intensities of the Raman lines and infrared bands exhibited by liquid BrF_5 at room temp. and gaseous BrF_5 at low pressures, respectively, in the frequency range 400–700 cm^{-1} are tabulated. W. R. Angus

535.343.4–15 : 535.375.56

2629. Infra-red and Raman spectra of diacetylene. A. V. Jones. *Proc. Roy. Soc. A*, **211**, 285–95 (*Feb.* 21, 1952).

These investigations lead to a new assignment of the vibrational spectrum which accounts for the observed overtone and combination bands. In particular, a new Raman band found at 874 cm^{-1} has been assigned to the C–C stretching mode ν_3. A normal co-ordinate treatment has been carried out using the new assignment and leads to a value for single bond C–C stretching force constant which appears satisfactory in all respects. A.

535.345–15

2630. Far-infrared transmission of silicon and germanium. R. C. Lord. Letter in *Phys. Rev.*, **85**, 140–1 (*Jan.* 1, 1952).

Infrared transmission for 2 mm samples of Ge and Si has been determined for the 260–800 cm^{-1} range. F. Lachman

535.361.2

2631. A new determination of the luminance factor of magnesium oxide. J. S. Preston and G. W. Gordon-Smith. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 76–80 (*Jan.*, 1952).

A simple, direct and absolute method of reflectometry is described, avoiding the use of the inverse square law, and overcoming several of the drawbacks of the selenium photovoltaic cell which is used for the measurements. These advantages are secured through the use of calibrated apertures and certain integrating properties of the cell. The result obtained for the luminance factor for white light of an MgO smoked layer 1 mm thick was 1·01 for normal incidence and 45° view. A.

535.371

2632. Recent developments in luminescent materials. S. T. Henderson. *Research* [*Lond.*] **4**, 492–7 (*Nov.*, 1951).

A review with bibliography of 105 items, mainly 1949–51.

535.371

2633. Energy levels and rate processes in the thallium activated potassium chloride phosphor. P. D. Johnson and F. E. Williams. *J. Chem. Phys.*, **20**, 124–8 (*Jan.*, 1952).

The dependence of spectral distribution and intensity of emission of KCl : Tl on temperature and excitation wavelength are correlated with absorption data and theoretical calculations to provide a detailed picture of the energy relationships in this phosphor. The two principal excited states are the $^1P_1^0$ and $^3P_1^0$ states of Tl^+ and are found to be approximately in thermal equilibrium with each other. The equilibrium is disturbed by emission, and the 4 750 Å emission is favoured by 1 960 Å excitation and the 3 050 Å emission is favoured by 2 470 Å excitation. The former processes are attributed to $^1P^0 \leftrightarrow {}^1S_0$ transitions; the latter, to $^3P_1^0 \leftrightarrow {}^1S_0$ transitions. The rate processes are formulated and the specific rate constants deduced. The presence of Tl^+ or Cd^{++} adjacent to the activator induces additional excitation and emission bands. The activation energy for radiationless de-excitation has been computed theoretically and found to be in accord with experiment. A.

535.371

2634. Originative and intensifier activators in MgO phosphors. R. H. Bube and K. D. Stripp. Letter in *J. Chem. Phys.*, **20**, 193–4 (*Jan.*, 1952).

Some impurities enhance the blue emission of pure MgO phosphors while others contribute their own emission spectra. Fe, Ni, Co and Cu act as poisons. Enhancing impurities are more effective at higher concentrations, but originative impurities are effective over a wide range of concentrations. G. F. J. Garlick

535.371

2635. Fluorescence of dyestuff solutions: viscosity and temperature effects. N. R. Tawde and N. Ramanathan. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 33–40 (*Jan.*, 1952).

The effect of viscosity and temperature of the medium on the polarization of the fluorescent light emitted by some dyestuff solutions when excited by linearly polarized monochromatic light is investigated by the visual and photoelectric methods. The variations in the polarization caused by temperature are found to depend on the concentration and molecular weight of the dyestuff. A.

535.371

2636. Experimentally derived configurational co-ordinate curves for phosphors. C. C. KLICK. Letter in *Phys. Rev.*, **85**, 154–5 (*Jan.* 1, 1952).

Configurational co-ordinates for the luminescence centres in KCl–Tl, $MgWO_4$, Zn_2SiO_4–Mn phosphors are constructed on basis of experimental data for absorption and emission spectra and for the vibrational frequency in the ground state. G. J. F. GARLICK

535.371

2637. The effect of inert gases on the quenching of fluorescence in the gaseous state. H. G. CURME AND G. K. ROLLEFSON. *J. Amer. Chem. Soc.*, **74**, 28–31 (*Jan.* 5, 1952).

The quenching of the fluorescence of β-naphthylamine by carbon tetrachloride in the gas phase has been studied with respect to its dependence on the wavelength of the exciting light and on the concentration of gases which are not in themselves quenchers. It has been found that the quenching constant is about one-fourth as large when $\lambda = 2\,537$–$2\,650$ Å is used for excitation than when $\lambda = 3\,130$ is used. This fact is in accord with Neporent's observations on the lifetimes with these modes of excitation. The addition of ethane or cyclohexane causes the apparent quenching constant to increase and it appears to approach a limiting value. This limit is independent of the nature of the added gas and of the light used for excitation. Such behaviour is explained by assuming that the effect of the added gas is to deactivate the photoexcited molecule to the lowest vibrational state of the first excited level. These facts are represented by a set of processes for which rate constants are deduced. The dependence of the apparent quenching constant on the concentration of the added inert gas has been expressed in terms of these constants and it is shown that the theoretical curve is in good agreement with the experimental observations. A.

535.371

2638. Long-lifetime phosphorescence and the diffusion process. P. DEBYE AND J. O. EDWARDS. *J. Chem. Phys.*, **20**, 236–9 (*Feb.*, 1952).

The long-lifetime phosphorescence of certain easily oxidizable organic compounds in rigid media at the temperature of liquid N has been found to decay by an inverse power function of the time. Decay kinetics of this type have been observed previously in inorganic phosphors. Employing the diffusion equation and the observed rate law, a distribution function for electrons in the solid media is derived. Data from the experiments are discussed in relation to this theoretical treatment. A.

535.371

2639. The location of the activator in fluorescent ZnS–Cu. F. A. KRÖGER. Letter in *J. Chem. Phys.*, **20**, 345–6 (*Feb.*, 1952).

Arguments are advanced against the interpretation of Bube's work [Abstr. 7762 (1951)] as a confirmation of the theory that ZnS phosphors prepared in presence of halogen ions take up an amount of halogen of the order of the concentration of the activator; and in favour of the theory of Kröger and Smit that the formation of Zn–Cu phosphors in an atm. of H_2S–HCl can be explained on the assumption of the existence of green and blue centres [Abstr. 5721 (1950)]. J. GRANT

535.371 : 537.37 : 539.2

2640. Transfer and transport of energy by resonance processes in luminescent solids. T. P. J. BOTDEN. *Philips Res. Rep.*, **6**, 425–73 (*Dec.*, 1951).

A distinction is made between those systems in which transport of energy may occur via the base lattice (described in Pt I) and the so-called sensitized systems in which transport may occur only via particular centres of the lattice (Pt II). Pt I deals with the investigations on alkaline-earth tungstates and molybdates activated with Sm. Upon excitation in the absorption band of the base lattice with ultraviolet radiation both the tungstate or molybdate and the Sm fluorescence are emitted at low temperatures (below about 250°K). At these temperatures the quantum efficiency of the Sm fluorescence is independent of temperature, while for excitation by certain wavelengths the quantum efficiency of the tungstate or molybdate fluorescence is temperature dependent, because the absorption changes with temperature. The excitation energy that leads to Sm fluorescence at low temperatures is mainly absorbed in tungstate or molybdate groups in the neighbourhood of the Sm ions and the energy is transferred from these groups to Sm. At the temperature at which the tungstate or molybdate fluorescence is quenched, or at a slightly higher temperature, the quantum efficiency of the Sm fluorescence increases with temperature due to the transfer of energy from tungstate or molybdate groups at larger distances from the Sm ions to these ions. This energy is transported from the groups first excited to groups in the neighbourhood of the Sm ions. The mechanisms of transfer and transport of energy are discussed. Calculations have been carried out on the basis of the theories of Mott–Seitz and of Möglich–Rompe for the quenching of fluorescence. The results are in favour of the theory of Mott–Seitz, but do not confirm that of Möglich–Rompe. In Pt II a number of sensitized systems are dealt with. Several explanations for the phenomenon of sensitization have in course of time been put forward, but only a few of them are borne out by the known experiments. It has been deduced that, on the basis of some of these theories, the ratio of the quantum efficiencies of the activator fluorescence and the sensitizer fluorescence will not increase with increasing sensitizer concentrations at constant activator concentrations. This is found to be in contradiction with the author's results obtained with the systems $Ca_3(PO_4)_2$–Ce–Mn, $Sr_3(PO_4)_2$–Sn–Mn, $Ca_5P_3O_{12}F$–Sb–Mn, $Ca_2P_2O_7$–Sn–Mn and also with Froelich's results on $Mg_2P_2O_7$–Ce–Th–Mn. An explanation of the experiments is given on the basis of: (1) a random distribution of the sensitizer and the activator ions; (2) direct transfer of energy from the sensitizer to the activator (by quantum-mechanical resonance) if the activator is situated in the neighbourhood of the sensitizer; (3) the assumption that if the excited sensitizer has not an activator in its neighbourhood the excitation energy may be transported via other sensitizer ions (by resonance) to a sensitizer that has an activator in its neighbourhood, followed by transfer

of the energy to the activator. The numbers of cation sites around a sensitizer, forming its neighbourhood, are calculated from the experiments on a few systems, for transfer both to an activator and to another sensitizer. The mechanisms of transfer and transport of energy are discussed on the basis of the theory of Mott and Seitz; the temperature dependence of sensitization may be explained in this way. A.

535.371 : 539.132

2641. Collisional perturbation of spin-orbital coupling and the mechanism of fluorescence quenching. A visual demonstration of the perturbation. M. KASHA. *J. Chem. Phys.*, **20**, 71–4 (*Jan.*, 1952).

A yellow colour is produced when two colourless pure liquids, α-chloronaphthalene and ethyl iodide, are mixed, although no chemical reaction occurs. Spectroscopic examination reveals that the lowest singlet → triplet absorption band of the naphthalene molecule is greatly enhanced in intensity in the presence of the iodide, and that the development of this absorption band is responsible for the colour effect. The process is interpreted in terms of a collisional perturbation of spin-orbital coupling in the π-electron orbitals of the naphthalene. The significance of this phenomenon in several topics in spectroscopy and chemistry is discussed. In particular, the molecular mechanism of heavy atom quenching of fluorescence by foreign species is resolved. A novel Beer's law anomaly is predicted for intercombinations. A.

535.375.5

2642. The Raman effect of vinylidene chloride. P. JOYNER AND G. GLOCKLER. *J. Chem. Phys.*, **20**, 302–6 (*Feb.*, 1952).

The Raman spectrum of vinylidene chloride is reported. An assignment of fundamental vibrational frequencies is made and the overtone and combination frequencies interpreted. A method of accurately marking faint Raman lines for measurement is described. A.

535.375.5

2643. The Raman spectra of methoxychlorosilanes. H. MURATA. Letter in *J. Chem. Phys.*, **20**, 347–8 (*Feb.*, 1952).

The spectra of CH_3OSiCl_3, $(CH_3O)_2SiCl_2$ and $(CH_3O)_3SiCl$ are tabulated and tentative assignations of the observed lines made. G. I. W. LLEWELYN

535.375.5 : 535.55 : 548.7

2644. On the relations between the photo-elastic properties and the Raman effect in crystals. O. THEIMER. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 38–45 (*Jan.*, 1952).

General relations are derived between Pockel's elasto-optical constants and the polarizability derivatives $\alpha_{\rho\sigma,\mu}\begin{pmatrix} l \\ kk' \end{pmatrix}$ used in Born's theory of the Raman effect in crystals. Numerical data are given for the case of diamond. Using these relations a formula is derived for the intensity of the Brillouin components of crystals in terms of the elasto-optical constants. This formula avoids the simplifications implied in an earlier expression due to Leontowitsch and Mandelstamm. A.

535.376

2645. Luminescence of solutions due to γ-rays detected by means of a 931 A photomultiplier. A. CICCONE. *Nuovo Cim.*, **9**, 36–43 (*Jan.*, 1952) *In Italian.*

Reports experiments performed to study the luminescence of solutions due to γ-rays, and the intensity variation of luminescence with changing concentration. Two possible qualitative explanations of the luminescence are reported. A.

535.376 : 537.311.33

2646. Light emission from silicon carbide. R. W. SILLARS. Letter in *Phys. Rev.*, **85**, 136 (*Jan.* 1, 1952).

A report of light emission from the region of the point contact on a silicon carbide crystal face. The emission is best seen by viewing through an opposite face from that on which the contact is made [see also Abstr. 8654 (1951)]. G. F. J. GARLICK

535.376 : 548.7

2647. On the scintillation mechanism in organic crystals. M. AGENO AND R. QUERZOLI. *R.C. Ist. Super. Sanità*, **14**, 779–91 (*No.* 10, 1951) *In Italian.*

Examines three processes *a priori* capable of accounting for the phenomenon of scintillation in organic crystals: (*a*) electronic excitation of the crystal; (*b*) ionization of the molecule; (*c*) excitation of the molecule and migration of excitation energy through the crystal. A qualitative consideration is made of the experimental data available today concerning the law of decadence of fluorescence with time, effect of temperature on the average life of fluorescence, conductivity associated with scintillations and transparence of crystals in their fluorescent light. The conclusion is that only the hypothesis (*c*) is not in disagreement with any experimental data under consideration. A.

535.417

2648. A symmetrical all-dielectric interference filter. H. D. POLSTER. *J. Opt. Soc. Amer.*, **42**, 21–4 (*Jan.*, 1952).

By replacing the Ag layers in the conventional interference filter with 7 dielectric layers having alternately high and low indices, it has been possible to obtain a filter having an 80% peak transmission and 65 Å half-width for a first-order transmission band centred at 5 200 Å. The properties of the filter are determined from the theory of the parallel-plate interferometer. A.

535.422

2649. On the theory of diffraction by concentric arrays of ring-shaped apertures. A. BOIVIN. *J. Opt. Soc. Amer.*, **24**, 60–4 (*Jan.*, 1952).

Lommel's problem, the diffraction of spherical waves by a circular aperture and opaque disk, is extended to the case of a concentric array of ring-shaped apertures with arbitrary distribution of circle radii. The evaluation of the diffracted amplitude resulting from the entire array by the obvious process of numerical summation, applied to amplitude expressions pertaining to the sequence of circles involved, is found unsuitable and, instead, series expansions are investigated in which the location of

the off-axis observation point and the interference effects of the ring openings are formally separated. The already available solutions of Lommel's problem are examined from this viewpoint, and two new expansions in complex power series are derived. By means of two novel multiplication theorems for Lommel's functions of two variables, convenient expansions in series of these functions are obtained for the amplitude diffracted by the annular array, thus affording the basis of a general theory of diffraction by ring systems, including the case of phase-reversal construction. Furthermore, equivalent general expressions are directly obtained from the power series formulae mentioned previously. A first application is made to the special case of the Soret zone plate. Finally Hopkins's assumptions of radially non-uniform amplitude is briefly dealt with in connection with the circular aperture and the annular systems. A.

535.43 : 541.18

2650. Optical transmission of certain colloidal solutions under relaxation conditions. G. KLEIN. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 40–8 (*Jan.*, 1952).

Formulae are derived for the variation in time of transmission of light through dilute colloidal solutions of uniaxial particles which are initially orientated by an external electric or magnetic field from the instant the field is removed. Two cases are considered: (i) particles opaque and large compared with the wavelength of light, and (ii) metallic particles small compared with the wavelength. A.

535.434 : 541.18 : 541.135

2651. Macro-ions. I. Light scattering theory and experiments with bovine serum albumin. P. DOTY AND R. F. STEINER. *J. Chem. Phys.*, **20**, 85–94 (*Jan.*, 1952).

The theory of light scattering is extended to include solutions of macro-ion salts such as charged proteins and polymeric electrolytes. Equations for the angular intensity distribution are obtained for three types of interaction potential: (1) that of rigid, non-interacting spheres; (2) an electrostatic potential consistent with the Verwey–Overbeek theory; and (3) a simple Gaussian-type repulsion. Because the repulsive forces between the macro-ions are generally strong and long-range, the concentration and angular distribution of the scattering may be very pronounced. Two unique and important extremes exist. If the concentration of the macro-ion salt is altered without introducing additional electrolytes, the effective diameter of the macro-ion is inversely proportional to the cube root of the concentration. In this situation the essential features of the scattering are quite novel. First, the reciprocal reduced intensity rises steeply from the intercept at zero concentration, bends over and becomes nearly horizontal at moderate concentrations, and second, the dissymmetry falls sharply from the limiting value at zero concentration, passes through a minimum and rises slowly at higher concentrations. With small particles the dissymmetry is always less than unity. In experiments with bovine serum albumin carrying charges up to 50 protons, all of these features have been found and can be accounted for at least semiquantitatively. The second unique case is that occurring when the concentration is altered by isoionic dilution which keeps the effective diameter of the macro-ion constant. Since it is shown that in the scattering problems the difference between the hard sphere and electrostatic potential is relatively minor, the virial coefficients of Boltzmann can be used to describe the concentration dependence of the absolute intensity of scattering. This procedure permits, in contrast to the previous case, a precise evaluation of the effective ionic diameter. The values so obtained are compared with the estimates from the Debye–Huckel theory. As a consequence of these investigations, it appears that both the thermodynamic behaviour and diffraction behaviour of macro-ion solutions are consistent with a relatively simple electrostatic picture. A.

535.55

2652. Apparatus for the measurement of internal strain in transparent media. O. MACEK. *Arch. tech. Messen, Issue No.* 191 (*Ref. V*1371–1) T133–T134 (*Dec.*, 1951) *In German.*

The theory of the detection and measurement of internal strain by polarized light is given. An apparatus, based upon the method of Tardy, is described. This is suitable for the measurement of refractive index differences as small as 4×10^{-7} and can be used on plane parallel plates, lenses or prisms. R. W. FISH

535.581 : 548.0

2653. Contribution to the study of the optical properties of crystals of Seignette salt. J. JAFFRAY. *Ann. Phys.* [*Paris*] **6**, 960–8 (*Dec.*, 1951) *In French.*

A review is given of the crystallography and optical properties of Seignette salt at different temperatures. The nature of the transformation at the Curie points is described. Details of measurements on the dispersion of the birefringence are given. The channelled spectra method of Fizeau–Foucault [see Abstr. 4251 (1949)] is used. The phenomenon of the crossing of the optic axes is described and the wavelength determined for which the crystal becomes uniaxial for temperatures of 20°, 0°, −79° and −183°C respectively. H. G. JERRARD

535.65 : 612.843.31 : 621.397.2

2654. Colour television: some subjective and objective aspects of colour rendering. G. T. WINCH. *Instn Elect. Engrs Paper* 1285, 7 *pp.* [*Early Proof Issue, Television Convention*, 1952].

After a brief review of the more general aspects of colour in television, attention is drawn to the subjective aspects of picture quality, both in monochrome and in colour. Reference is made to earlier work on a somewhat similar problem of colour rendering in which the binocular matching technique has given promising results. Based on this experience, apparatus and methods are described which should facilitate the study of the subjective requirements under different conditions of presentation and view. These requirements could then be related to the objective photometric and colorimetric measurements carried out by physical instruments indicating directly in the C.I.E. system. The interest shown by the C.I.E. in colour television is mentioned and their 1951 resolutions on this subject are recorded. A.

535.8

2655. Focussing Schlieren systems. R. W. Fish and K. Parnham. *Aero Res. Coun.* (*Min. of Supply*) *Curr. Pap. No.* 54, 14 *pp.* (1951).

The substitution of grids for the usual knife edges in a Schlieren apparatus confers focusing properties on the system. Three possible systems are described and their optical limitations discussed. Achromatic lenses are used in place of mirrors because of the excessive off-axis aberrations of the mirrors. Some practical suggestions for the construction of the grid and the adjustment of the system are given. A.

535.822.9

2656. Notes on the explanation of phase contrast microscopy. W. Lippert. *Optik*, **8**, 543–9 (*No.* 12, 1951) *In German.*

The phase contrast method is explained in a simple, but general, manner which will allow some quantitative results to be obtained. R. W. FISH

535.822.9 : 535.41

2657. Multiple-beam interference microscopy. R. C. Faust. *Proc. Roy. Soc. A*, **211**, 240–54 (*Feb.* 21, 1952).

The diffraction theory of multiple-beam interference microscopy is here developed by regarding the object under study as a phase grating; a comparison is made with the two other forms of microscopy. With multiple-beam interference microscopy (Tolansky, 1948) the phase and amplitude of each diffracted beam are changed to an extent determined by the phase and amplitude of all the other diffracted beams. This relationship prevents one from modifying a given beam without influencing all the others. When the interferometer is viewed in reflection these modified diffracted waves are superimposed upon a coherent background, so that, when the interferometer reflectivity is low, the arrangement produces effectively two-beam interference. As the lateral structure of the object becomes finer, the image formed by multiple-beam interference becomes a less faithful portrayal of the object structure; the extent of this infidelity is enhanced as the reflectivity, gap and wedge angle of the interferometer are increased. The advantage of multiple-beam interference is the high accuracy with which phase differences within the object can be measured. A.

535.89 : 537.541 : 621.325.13

2658. A discharge illuminant for optical systems capable of either continuous or flash operation. E. J. G. Beeson and A. A. Webb. Letter in *Nature* [*Lond.*] **168**, 1038–9 (*Dec.* 15, 1951).

Describes a xenon-filled lamp capable of use at a low level of illumination or as a high-intensity flash source. In the latter case the lamp will discharge 200 joules at about 5 sec intervals, and operated continuously at 150 W the maximum brightness is about 1 000 stilb. J. D. CRAGGS

HEAT 536

536.2.01

2659. A problem in heat conduction. W. Squire. Letter in *J. Appl. Phys.*, **22**, 1508–9 (*Dec.*, 1951).

A simple derivation is given for the steady state temperature field due to a heat source moving with constant velocity when the source varies as $e^{i\omega t}$. Results for a constant, sine, cosine and $(1 - \cos \omega t)$ source are readily obtained from the resulting expression. E. H. DOCK

536.2.02 : 551.524

2660. Heat conduction in the region bounded internally by an elliptical cylinder and an analogous problem in atmospheric diffusion. C. J. Tranter. *Quart. J. Mech. Appl. Math.*, **4**, 461–5 (*Dec.*, 1951).

A formal solution is given for the heat flow. A particular case is used in the problem of atmospheric diffusion over a saturated surface in the form of a long rectangular strip when wind speed and diffusivity are constant with height. L. S. GODDARD

536.21 : 537.31 : 536.48

2661. The thermal and electrical conductivity of copper at low temperatures. R. Berman and D. K. C. MacDonald. *Proc. Roy. Soc. A*, **211**, 122–8 (*Feb.* 7, 1952).

Following previous work on Na, the thermal and electrical conductivity of Cu has been measured continuously between 90 and 2°K. The specimen was of spectrographic purity, and had been found to have a pronounced minimum in the electrical resistance at about 10°K. A similar, but smaller, anomaly was observed in the thermal resistivity with a corresponding small deviation from the Wiedemann–Franz law at the lowest temperatures. As in the case of Na, marked disagreement with theory was found in the temperature variation both of the thermal conductivity and of the Lorenz number. A.

536.221

2662. Thermal conductivity of liquid sodium and potassium. C. T. Ewing, J. A. Grand and R. R. Miller. *J. Amer. Chem. Soc.*, **74**, 11–14 (*Jan.* 5, 1952).

Conductivity coefficients were measured with a longitudinal heat flow apparatus—Na to 510° and K to 610°. A description of an apparatus for accurate measurement of high boiling metals to 600° is presented. The ideality of the pure liquid metal media is shown by the conformation of the conductivity values to empirical and theoretical postulations. A.

536.24

2663. A nonsteady heat diffusion problem with spherical symmetry. M. S. Plesset and S. A. Zwick. *J. Appl. Phys.*, **23**, 95–8 (*Jan.*, 1952).

A solution in successive approximations is presented for the heat diffusion across a spherical boundary with radial motion. The approximation procedure converges rapidly provided the temperature variations are appreciable only in a thin layer adjacent to the spherical boundary. An explicit solution for the temperature field is given in the zero order when the temperature at infinity and the temperature gradient at the spherical boundary are specified. The first-order correction for the temperature field may also be found. It may be noted that the requirements for rapid convergence of the approximate solution are satisfied for the particular problem of the growth or collapse of a spherical vapour bubble in a liquid when the translational motion of the bubble is neglected. A.

536.24

2664. Heat transfer in isotropic turbulence. S. CORRSIN. *J. Appl. Phys.*, **23**, 113–18 (*Jan.*, 1952).

The postulated problem of heat transfer in a stationary isotropic turbulence under constant small temperature gradient is examined from both Lagrangian and Eulerian points of view. By combination of Taylor's "diffusion by continuous movements" and a new temperature fluctuation equation somewhat like the well-known turbulent energy equation, it is possible to obtain (1) an expression for the turbulent heat transfer coefficient which depends only on velocity field, and (2) an approximate expression for the corresponding correlation coefficient which depends only on velocity field and fluid physical properties. A preliminary result is given for "turbulent Prandtl Number" in a homogeneous shear flow in terms of the shear and heat transfer correlation coefficients. A.

536.25

2665. Measurement of convection coefficients at high velocities and at high temperatures. E. BRUN AND M. PLAN. *C.R. Acad. Sci.* [*Paris*] **234**, 54–6 (*Jan.* 2, 1951) *In French.*

A German silver tube of external diameter 10 mm and thickness 0·25 mm, capped by an arch at its upstream end, and arranged in an air stream produced by a blower, so that its axis is parallel to the flow of air, is heated to about 850°c by an electric current of about 700 A traversing a length of about 60 mm of the tube. Electric connections with the tube are provided by two double tubes carrying cold water, one pair passing inside the German silver tube and joining up with the arch, the other pair being soldered to a sleeve on the down-stream part of the tube, which, being traversed by cold water, limits the length of the German silver tube heated. The temperature along the length of the tube being measured (by an optical pyrometer), the electric energy supplied being measured, and the heat convected by the water being determined, the heat convected from the German silver tube can be ascertained. Preliminary results, obtained at subsonic flows, with Mach numbers 0·35–0·75, and at supersonic flows, with Mach numbers 1·90, 2·40 and 2·95, are briefly discussed. J. S. G. THOMAS

536.27

2666. Measurements on heat exchangers. O. HOLFELDER. *Arch. tech. Messen, Issue No.* 190 (*Ref. V*8230–2) T123–T125 (*Nov.*, 1951) *In German.*

The fundamental principles of fluid heat exchangers are discussed and the methods and instruments for the measurement of quantity, temperature and pressure in heat exchangers are reviewed. 38 refs. S. WEINTROUB

536.421.1

2667. A note on kinetics of fusion. V. S. NANDA. *Proc. Nat. Inst. Sci. India*, **17**, 239–40 (*July–Aug.*, 1951).

Furth's theory [*Proc. Camb. Phil. Soc.*, **37**, 252 (1941)] is applied to the kinetics of fusion and using Penner's expression, $\nu \exp(-\varepsilon_f/kT)$, for the rate of fusion [Abstr. 2466 (1949)] where ν is the Lindemann frequency and ε_f the latent heat of fusion, it is shown that $\nu = 2{\cdot}2(\sigma/m)^{\frac{1}{2}}$ where σ is the surface tension and m the molecular mass. S. WEINTROUB

536.421.4.031 : 551.574.1

The spontaneous crystallization of supercooled water. *See Abstr.* 3148

536.423.15

2668. On the measurement of vapor pressures by effusion. C. I. WHITMAN. *J. Chem. Phys.*, **20**, 161–3 (*Jan.*, 1952).

The effect of apparatus dimensions on the accuracy of vapour pressure measurements by Knudsen's effusion method is discussed for the usual type of experimental arrangement. It is shown that the total surface area of a condensed solid phase is not fundamentally related to the pressure of the effusing vapour. Equations are derived which may be used to check the pressure of the effusing vapour for saturation. Two cases in the literature are discussed. A.

536.423.15

2669. The vapor pressures of tellurium and selenium. L. S. BROOKS. *J. Amer. Chem. Soc.*, **74**, 227–9 (*Jan.* 5, 1952).

The pressures have been measured with quartz Bourdon gauges, with the following results: Te, $A = 7{\cdot}5999 \pm 0{\cdot}0136$; $B = 5\,960{\cdot}2 \pm 14{\cdot}5$; $T_b = 989{\cdot}8 \pm 3{\cdot}8$; $L_v = 27{\cdot}26 \pm 0{\cdot}07$. Se, $A = 8{\cdot}0886 \pm 0{\cdot}0048$; $B = 4\,989{\cdot}5 \pm 4{\cdot}5$; $T_b = 684{\cdot}9 \pm 1{\cdot}0$; $L_v = 22{\cdot}82 \pm 0{\cdot}02$. A and B are constants in the equation $\log p = A - B/T$, p is the pressure in mm, T the absolute temperature, T_b the boiling point in degrees c and L_v the latent heat of vaporization in kcal./mole, the probable errors being stated in each case. A.

536.423.4

2670. The supersaturation of nitrogen in a hypersonic wind tunnel. I. FARQ, T. R. SMALL AND F. K. HILL. *J. Appl. Phys.*, **23**, 40–3 (*Jan.*, 1952).

Tests in a small hypersonic wind tunnel have determined critical temperature and pressure conditions for the condensation of pure dry N and have indicated that in the range of pressure (0·5–2·8 mm Hg) and temperature (52°–64°R) obtained in the tests, there is a supersaturation of about 30 Fahrenheit degrees. A.

536.423.4

2671. On the early stages of condensation of rare-gas type molecules. S. G. REED, JR. *J. Chem. Phys.*, **20**, 208–11 (*Feb.*, 1952).

The early stages of condensation are treated from the standpoint of the associative equilibrium of single molecules and stable molecular aggregates. Formulae are presented for partition functions from which one can calculate standard chemical potentials and concentrations of specified configurations of up to 8 molecules having a Lennard–Jones (6–12) interaction. Numerical results are given for N. It appears that N aggregate concentrations fall steeply with decreasing temperature. Results of this procedure, using a restricted region of phase space, are compared with those obtained with no restrictions for 2 and 3 molecule aggregates. A.

536.424 : 548.736.4

2672. Phase transition of $ND_4D_2PO_4$. B. T. MATTHIAS. Letter in *Phys. Rev.*, **85**, 141 (*Jan.* 1, 1952).

$NH_4H_2PO_4$ does not become ferroelectric as does KH_2PO_4, but undergoes a transition at 148°K. $ND_4D_2PO_4$ shows the same at 242°K. Therefore the transition is believed to be an order-disorder effect of X_2PO_4(X = H or D); the non-spherically symmetric ammonium ion prevents ferroelectricity.

A. J. TAYLOR

536.44 : 536.63

2673. Thermodynamics of the critical point. W. G. SCHNEIDER AND A. CHYNOWETH. Letter in *J. Chem. Phys.*, **19**, 1607 (*Dec.*, 1951).

A previous suggestion by Curtiss, Boyd and Palmer [Abstr. 6939 (1951)] for determinations of C_v at the critical point from measurements of the velocity of sound is criticized. It is considered that unless the sound velocity determinations are made at very low frequencies large errors may occur. These arise from configurational relaxation processes which make the elasticity time-dependent, and hence the value from sound velocity measurements greater than the static value. For CO_2 and C_2H_4 the calorimetric values of C_v are greater than those from acoustic and isotherm data.

F. E. HOARE

536.46

2674. A simplified theory of the height of laminar diffusion flames. F. GUYOMARD. *C.R. Acad. Sci.* [*Paris*] **234**, 67–9 (*Jan.* 2, 1952) *In French.*

The solution of the problem is approached in three successive stages of approximation. It is firstly assumed that gaseous fuel and ambient oxidant are brought together as two coaxial cylindrical streams moving with equal velocity at const. temp., and simple diffusion of the oxidant into the fuel is investigated on the assumption that the diffusion coeff. (δ) is constant. The next stage in the approximation is to allow for the increase in gas-temperature (T) as the combustion reaction proceeds; it is assumed that δ varies as T^n where $n \simeq 2$. In the final approximation, the velocities of fuel and oxidant are considered unequal, that of the oxidant being zero. It is concluded that the flame height h is given by $h = 2Q_0T_0/5{\cdot}76\pi\delta_0T_m$ where Q is the (volume) rate of fuel-flow, subscript o refers to ambient conditions, and T_m is a mean flame temperature: satisfactory agreement with experimental results is claimed. [The treatment of the problem is discussed in general terms, and the results are quoted without detailed derivation.]

A. SCHOFIELD

536.46 : 535.343

2675. A spectroscopic investigation into the structure of diffusion flames. H. G. WOLFHARD AND W. G. PARKER. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 2–19 (*Jan.*, 1952).

Ammonia-oxygen, ethylene-oxygen and other diffusion flames were examined spectroscopically using the flat flame technique described in Abstr. 834 (1950). Each flame is shown to consist of a main reaction zone where the temperature is a maximum. The emission from this zone is thermal, and the component gases are in chemical equilibrium. On either side of the main reaction zone there is a region with a steep temperature gradient which constitutes a pre-heating zone. Fuels such as hydrocarbons or ammonia and oxidizers such as nitric oxide undergo chemical change in these pre-heating zones. On the fuel side the change is principally a thermal decomposition because the main reaction zone presents a barrier to oxygen penetration. Thus carbon formation in hydrocarbon diffusion flames is essentially a pyrolytic process. The application and value of absorption spectroscopy are discussed and quantitative measurements of the concentrations of molecular oxygen and OH radicals are recorded which could not have been otherwise obtained. These results and a number of qualitative observations clearly show that diffusion flames with oxygen at atmospheric pressure have the structure predicted for a flame in which diffusion is the rate determining process. A number of differences are described between the characteristics of diffusion and pre-mixed gas or Bunsen flames.

A.

536.461

2676. Nonisotropic propagation of combustion waves in explosive gas mixtures and the development of cellular flames. J. MANTON, G. VON ELBE AND B. LEWIS. *J. Chem. Phys.*, **20**, 153–6 (*Jan.*, 1952).

The phenomenon of non-isotropic propagation consists in the spontaneous development of blisters or cells on the surface of a combustion wave. The present experiments on spherical flames and the experiments of Markstein on flames in wide tubes show that the phenomenon is characteristic of non-stoichiometric explosive mixtures in which the deficient reactant constituent is also the constituent of largest diffusivity. This suggests that the phenomenon is primarily caused by the effect of diffusion processes on the burning velocity. It is proposed that in curved areas of the wave that are convex with respect to the burned gas, the burning velocity is reduced because the lines of diffusion diverge, and hence the concentration of the faster diffusing constituent decreases; whereas in concave areas the lines of diffusion converge, and hence the concentration of the faster diffusing constituent increases. In rich mixtures of hydrocarbon and oxygen, additional evidence for the effect is furnished by the emergence of carbon streamers and by characteristic changes of light emission from convex wave areas, showing that the oxygen concentration, and probably therefore the burning velocity, is decreased in these areas below the average for the mixture.

A.

536.48

2677. The melting pressure of He^3. B. WEINSTOCK, B. M. ABRAHAM AND D. W. OSBORNE. Letter in *Phys. Rev.*, **85**, 158–9 (*Jan.* 1, 1952).

Previous measurements [Abstr. 5359 (1951)] extended down to 0·16°K. Below 0·5°K the experimentally determined pressures seem to approach a constant value of 29·3 atm.

R. B. DINGLE

536.48

2678. Experiments with oscillating disk systems in liquid helium II. A. C. HOLLIS-HALLETT. *Proc. Roy. Soc. A*, **210**, 404–26 (*Jan.* 7, 1952).

An experimental study has been made of the period

and logarithmic decrement of a single disk and of a pile of equally spaced disks performing torsional oscillations in liquid He II. For small amplitudes (less than about 0·1 radian), the decay of amplitude is exponential, and from the solution of the Navier–Stokes equation deduced in the appendix, values of the viscosity were deduced from the results obtained with the single disk, and of the density of the normal component of He II from the results from the pile of disks; the values found are in good agreement with earlier work. For larger amplitudes, the logarithmic decrement of both systems increases considerably with amplitude, and for the pile of disks the period also increases with amplitude. From the increase of period, it is concluded that the superfluid component is dragged more and more with the disk system at higher velocities, while the increase of decrement is interpreted as being due to additional frictional forces associated with the dragging of the superfluid component. The mutual frictional force proposed by Gorter and Mellink proves inadequate to explain the observed effects. A.

536.48

2679. Thermal Rayleigh disk measurements in liquid helium II. J. R. PELLAM AND W. B. HANSON. *Phys. Rev.*, **85**, 216–26 (*Jan.* 15, 1952).

The torque exerted by heat flow on a disk suspended in liquid helium II has been measured and shown to agree with theoretical values. As reported earlier by P. M. Morse and one of the authors, such a disk constitutes a direct mechanical detector of the internal fluid convection currents associated with heat current in helium II. Thus the device is capable of detecting second sound mechanically, whereas ordinary microphones (either pressure or velocity type) do not respond. Furthermore it provides a direct measure of second sound intensity in terms of fundamental quantities, such as kinetic energy density and the geometry. The agreement between observed torque on the disk and predictions based on the two-fluid theory lend further credence to the internal consistency of that hypothesis. Behaviour within various temperature ranges, between 1·2°K and the λ-point, strongly implies that both the normal fluid and superfluid components exert their respective contributions to torque on the disk, as if each fluid individually obeyed the classical König formulae. That the disk recognizes the net torque exerted by both fluids in a manner conforming to this extension of the original classical hydrodynamics indicates that Bernoulli type forces (and the resultant couples) are associated with each separate fluid component, and with the heat current as a whole. The resultant generalized Bernoulli relationship earlier reported by Morse and one of the authors to hold near the λ-point has now been verified throughout the entire liquid helium II temperature range down to 1·2°K. In view of the generalized form of this principle it would appear that for the majority of classical hydrodynamical devices and experiments there exists the thermal counterpart in liquid helium II. In the present investigation, calculations are based on the numerical values of heat content TS measured for helium II by Kapitza in total flow experiments (through semi-permeable apertures). The present correlations concern alternatively observing by mechanical means the heat current in internal counterflow (no total flow). Employed as a calorimeter the thermal Rayleigh disk yields values of specific heat c_v for liquid helium II in conformity with values obtained earlier by other investigators using customary methods. A.

536.52

2680. The spectrum-line reversal method of measuring flame temperature. A. G. GAYDON AND H. G. WOLFHARD. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 19–24 (*Jan.*, 1952).

Processes of electronic excitation in flames are briefly discussed, and it is shown that if there is lack of equilibrium the reversal temperature may be closer to the effective vibrational temperature of the surrounding molecules than to the mean translational temperature. The lack of radiative equilibrium in all flames will cause measured temperatures to be too low; for a flame with air at 2 000°K using Na the error will be between 3·3° and 1·6° at 1 atm. and more at lower pressure. For hot flames, above 2 700°K, the OH band may be used for reversal measurements; it appears to give satisfactory results and has some advantages over the use of sodium. A.

536.631

2681. The electronic specific heat in chromium and magnesium. S. A. FRIEDBERG, I. ESTERMANN AND J. E. GOLDMAN. Letter in *Phys. Rev.*, **85**, 375–6 (*Jan.* 15, 1952).

Describes measurements of the specific heat between 1° and 4°K. Values of the linear low temperature electronic heat coefficient, γ, are deduced. For Cr $\gamma \times 10^4 = 3 \cdot 74$, for Mg $3 \cdot 25$ cal. mol^{-1} deg^{-2}. The fact that γ for Cr is rather low is discussed theoretically. The bearing of the measurements on recent suggestive interpretations of the low temperature resistance minimum in Mg is also discussed.

E. P. WOHLFARTH

536.653

2682. Calorimetric study of the precipitation of carbon dissolved in α-iron. G. BORELIUS AND S. BERGLUND. *Ark. Fys.*, **4**, 173–82 (*Paper* 4, 1951).

Specimens of technically pure Fe with small C contents were first heated at various temperatures between 350 and 700°C to obtain the corresponding equilibrium between C in solution in α-Fe and in cementite, Fe_3C; they were then quenched to 0°C and aged at temperatures between 80 and 130°C. During ageing, the power of the heat evolved by precipitation of C as carbide was measured as a function of time, and by integrating the power-time curves, the total amounts of heat computed. From this heat and its dependence on temperature, thermodynamic calculations give the heat of solution per mol and the solubilities of C at various temperatures. A.

536.68

2683. The study of the thermal behaviour of structures by electrical analogy. G. BURNAND. *Brit. J. Appl. Phys.*, **3**, 50–3 (*Feb.*, 1952).

The application of the analogy to the study of heating in dwellings, the maximum size of the units of capacity and resistance in the electrical models, and the methods of connecting up the model components are discussed. Electronic equipment for use

with electrical models of houses is described briefly. Comparisons with observed temperature data in a room agreed with electrical model results when the model was modified to account for the presence of temperature gradients and hot air streams in the actual room. A.

THERMODYNAMICS 536.7/.8

536.7

2684. On the transport of energy by conduction. J. E. VERSCHAFFELT. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 509–24 (*No.* 6, 1951) *In French.*

Extending the approximation beyond the zeroth degree, where the specific magnitudes are considered simply as functions of the state, it is now supposed that these magnitudes depend also on the temperature and concentration gradients. In this way the flux of internal energy and of entropy, which do not operate by convection but by conduction, are introduced into the fundamental equations of thermo-mechanics.

F. E. HOARE

536.7

2685. On the thermo-mechanics of irreversible phenomena. J. E. VERSCHAFFELT. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 691–5 (*No.* 8–9, 1951) *In French.*

A note correcting errors arising in a previous paper [Abstr. 6184, 1951)] from the incorrect neglect of some terms. The new consequences are derived.

F. E. HOARE

536.7 : 532.77

2686. Application of the cell method to the statistical thermodynamics of solutions. I. PRIGOGINE AND V. MATHOT. *J. Chem. Phys.*, **20**, 49–57 (*Jan.*, 1952).

The cell method for pure liquids in the form used by Lennard–Jones and Devonshire is extended to solutions. It is assumed that (*a*) the constituents are spherical in shape, with an isotropic field of force, (*b*) the distance of the maximum interaction for *AA*, *BB* and *AB* pairs is about the same, and (*c*) there is random mixing. For the mean field in the "cage," the complete 6–12 law, the harmonic oscillator and the smoothed potential model have been studied. The smoothed potential model (potential curve with vertical walls and flat bottom, both depth and width depending on concentration) fits the liquid state best. For this model, one obtains important corrections on both the heat of mixing and the excess entropy to the classical, strictly regular solutions. These corrections are related to the volume changes on mixing resulting from the changes of interactions. According to the value of ε_{AB}^*, the excess properties such as volume, entropy, heat of mixing and free energy present a large variety of shapes, including dissymmetry and inversions which correspond rather nicely to experimental evidence. This model permits discussion of the severe limitations of Longuet–Higgins's recent theory of conformal solutions. A.

536.7 : 533.7 : 534.22

Determination of thermodynamic and kinetic constants of gases and liquefied gases at low temperatures. *See Abstr.* 2501

536.75 : 530.162

2687. Information and thermodynamics. J. ROTHSTEIN. Letter in *Phys. Rev.*, **85**, 135 (*Jan.* 1, 1952).

The statements arising from the analogy between information, as defined in communication theory, and statistical entropy are summarized. The informational interpretation of the first law and quantity of heat is considered and it is shown to lead to Caratheodory's principle. A statement is given of the laws of thermodynamics derived in this manner [see also Abstr. 58 (1952)]. F. E. HOARE

ELECTRICITY 537

THEORY . ELECTRONS 537.1

537.12 : 530.162

2688. A collective description of electron interactions. II. Collective *vs.* individual particle aspects of the interactions. D. PINES AND D. BOHM. *Phys. Rev.*, **85**, 338–53 (*Jan.* 15, 1952).

For Pt I, see Abstr. 5379 (1951). The behaviour of the electrons in a dense electron gas is analysed in terms of their density fluctuations. These density fluctuations may be split into two components. One component is associated with the organized oscillation of the system as a whole, the so-called "plasma" oscillation. The other is associated with the random thermal motion of the individual electrons and shows no collective behaviour. It represents a collection of individual electrons surrounded by comoving clouds of charge which screen the electron fields within a distance of the order of magnitude of the Debye length. This split-up of the density fluctuations corresponds to an effective separation of the Coulomb interaction into long-range and short-range parts; the separation occurs at roughly the Debye length. The relation between the individual and collective aspects of the electron gas is discussed in detail, and a general physical picture of the behaviour of the system is given. It is shown that for phenomena involving distances greater than the Debye length, the system behaves collectively; for distances shorter than this length, it may be treated as a collection of approximately free individual particles, whose interactions may be described in terms of two-body collisions. This approach is used to study the interaction of a specified electron with the remainder of the electron gas. It is shown that the collective part of the response of this remainder to the field of the specified particle screens this field within a distance of the order of the Debye length; this furnishes a detailed description of the screening process. Moreover, if the specified particle moves with greater than the mean thermal speed, it excites collective oscillations in the form of a wake trailing the particle. The frequency of these collective oscillations and the energy emitted by the particle are calculated. A correspondence theoretical method is used to treat this phenomenon for the electrons in a metal. The generalization of these methods to an arbitrary interparticle force is carried out, and a

criterion is obtained for the validity of a collective description of the particle interactions. It is shown that strong forces and high particle density favour collective behaviour, while high random thermal velocities oppose it. A.

537.122 : 538.113

Diamagnetism of free electrons. *See Abstr.* 2825

ELECTROSTATICS . DIELECTRICS 537.2

537.212 : 539.42

2689. On the behavior of fibrous and powder materials under the intense electrostatic field. C. MATSUDA AND M. MOTOKI. *Tech. Rep. Engng Res. Inst. Kyoto Univ.*, **1**, 29–51 (*No.* 3, 1951).

The field was generated between the plates of a parallel plate condenser and was either d.c. or low frequency a.c. of up to 14 kV/cm. It was found that for cotton yarn the strength of an individual yarn was increased by up to 12% by the application of a.c. fields. For rayon yarn there was an increase of strength for d.c. fields and a decrease for a.c. fields. Experiments were also made on electrostatic methods of sizing particulate material by the application of the field. It was also found that the presence of particles decreases the sparking potential for a d.c. field.

J. M. HOUGH

537.22 : 621.38

2690. The elementary cases of the expansion of space-charge clouds. H. KLEINWÄCHTER. *Funk u. Ton*, **6**, 25–8 (*Jan.*, 1952).

Derives expressions for the expansion of homogeneous space-charge clouds, initially at rest in field-free space. Cylindrical, spherical and disk-shaped clouds are treated. A. H. W. BECK (R)

537.224 : 621.3.011.4

2691. Calculation of the capacitance of a circular annulus by the method of subareas. T. J. HIGGINS AND D. K. REITAN. *Trans Amer. Inst. Elect. Engrs*, **70**, 926–31 (*Pt I*, 1951).

The method consists in dividing the main area into elements over each of which the charge density is assumed uniform, and which are of such form that their separate contributions to the potential can be calculated. By summation, at each element, of the separate contributions to the potential, a set of equations is obtained which can be solved for the elementary charge densities. The total charge is thus known in terms of the potential, and the capacitance follows immediately. Good accuracy can be obtained even with only a small number of elements, and a universal curve of capacitance against annulus dimensions is given. The method has also been applied to the determination of the capacitance of a cube [Abstr. 2660 (1951)]. G. D. SIMS (R)

537.226.2

2692. The permittivity of solvents as a function of temperature. T. ERBEN. *Istanbul Tek. Üniv. Bül.*, **3**, 45–60 (*No.* 1, 1950) *In French.*

The empirical formulae for the variation of permittivity ε of solvents with absolute temperature T, derived by Morgan and Lowry (1930) and Walden (1909) are shown to be particular cases of a general expression; $\log(\varepsilon T) = A + BT + CT^2$. The second derivative of the function $(\log \varepsilon T)$ is constant and shown from the results of Åkerlöf and Short (1936) to be independent of the nature of the solvent. The relation between ε and T may therefore be deduced from only two experimental values. J. H. MASON

537.226.2

2693. Field dependence of the dielectric constant. J. J. O'DWYER. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1125–32 (*Dec.*, 1951).

A very general calculation has been made by Fröhlich giving the dielectric constant of a material in terms of the spontaneous fluctuations of the electric moment of the material which would occur in a field-free region. This calculation is now extended one step further so as to include the first term in the field dependence of the dielectric constant. By way of illustration the general theory is applied to Kirkwood's model for a dipolar liquid. (In order to preserve continuity of argument it has been found necessary to reproduce much of Fröhlich's work.) A.

537.226.2

2694. Two kinds of phenomena represented by the temperature change of the dielectric constant and the absorption in the centimetre-wave region of some ammonium salts. M. FREYMANN. *C.R. Acad. Sci.* [*Paris*] **233**, 1449–50 (*Dec.* 3, 1951) *In French.*

Measurements conducted with various NH_4 salts in powder form at temperatures from −150 to +30°C, and with a frequency of 9 560 Mc/s (3·138 cm), have shown that (1) $NH_4Al(SO_4)_2.12H_2O$, $NH_4Fe(SO_4)_2.12H_2O$, $(NH_4)_2Cr_2O_7$, and NH_4 chlorostannate display a continuous phenomenon of Debye, and the position of the maximum of v_c depends to a large extent upon temperature, while (2) dry $(NH_4)_2SO_4$ and NH_4NO_3 display a discontinuous phenomenon, and v_c does not vary considerably with temperature.

F. LACHMAN

537.226.2

2695. Measurement at high frequency of the dielectric constant of aqueous saline solutions. A. CARRELLI AND L. RESCIGNO. *Nuovo Cim.*, **9**, 1–4 (*Jan.*, 1952) *In Italian.*

Measurement has been made at high frequency ($\omega = 4{\cdot}39 \times 10^7$) of the dielectric constant of water in which some electrolyte has been dissolved. It has been found that increasing the concentration c, the dielectric constant of the water diminishes and afterwards increases and the minimum has been ascertained to be when c is in the range of 10^{-3}. A.

537.226.2

2696. Ferroelectricity and antiferroelectricity of a crystal containing rotatable polar molecules. Y. TAKAGI. *Phys. Rev.*, **85**, 315–24 (*Jan.* 15, 1952).

Describes the investigation of a CsCl type crystal made up by insertion of ions into the body centre sites of a simple cubic array of rotatable polar molecules. Owing to the Lorentz field exerted by the dipoles themselves, a non-uniform distribution in

orientation of the polar molecules is predicted below a certain critical temperature. The main results obtained are as follows: (1) It is shown that the crystal is antiferroelectric so long as the polarizability of the central ions is small, half of the dipoles being partially oriented parallel to and the other half anti-parallel to one of the cube edges. On the other hand, if the polarizability of the ions is larger than a certain threshold value, the crystal is ferroelectric, all the dipoles being partially oriented parallel to each other. (2) The dielectric-constant/temperature curves calculated for antiferroelectric cases show a variety of forms according to the polarizabilities of both components. For some specimens they are almost flat throughout the region around their own critical temperatures, while for other specimens they can show such sharp peaks that they are hardly discernible from those of ferroelectric crystals, which always show very sharp peaks tending to infinity. (3) Below their respective critical temperatures, the dielectric constant should decrease with increasing d.c. bias in a ferroelectric crystal, while in an antiferroelectric crystal it should increase slightly under the same condition. (4) If a sufficiently strong field is applied to an antiferroelectric crystal at just below its critical temperature, it will be forced to make a momentary transition to a ferroelectric one, the change being accompanied by an abrupt increase of polarization. It is suggested that most of the phenomenological predictions derived with this model may, qualitatively at least, be valid also for other models which have ions capable of displacement instead of freely rotatable dipoles, as is really the case with the well-known $BaTiO_3$ and the like. A.

537.226.2

2697. Dielectric properties of solid hydrogen bromide. N. L. Brown and R. H. Cole. Letter in *J. Chem. Phys.*, **20**, 196 (*Jan.*, 1952).

The complex dielectric constant below the transition point at 89°K is given and briefly discussed. D. H. WHIFFEN

537.226.2 : 538.569.3

2698. Measurement of the dielectric constants and the absorption coefficients of gases and vapours at hyperfrequencies [microwave frequencies]. A. Gennaoui. *Helv. Phys. Acta*, **24**, 401–18 (*No.* 5, 1951) *In French.*

Details of a reflection cavity method for determining ε' from the change of resonance frequency and ε'' from the change of transmission of a separate cavity giving α to $0{\cdot}005 \times 10^{-4}$ neper-cm^{-1} at 3·17 cm are given. Values are obtained for $CHCl_3$, CH_3COCH_3, $(C_2H_5)_2O$, C_2H_5OH, C_6H_6, C_2H_5Cl, NH_3 and CCl_4 at various pressures. D. H. WHIFFEN

537.226.2 : 539.133

2699. Dielectric constant measurements of chlorine trifluoride at 9 400 Mc/sec. D. W. Magnuson. *J. Chem. Phys.*, **20**, 229–32 (*Feb.*, 1952).

The dielectric constant was determined by measuring the change in the resonant frequency of a cavity when filled with the vapour. Corrections were made for the amount of dimer formed. The monomer molar polarization was best represented by $P = 15{\cdot}994 + 1\,882{\cdot}0/T°\text{K}$ cm^3 and the dipole moment was 0·554 Debye unit. The average dimer molar polarization was found to be 49·8 cm^3 assuming no dipole moment. A.

537.226.2 : 621.317.335.3.029.6

2700. Balance methods for the measurement of permittivity in the microwave region. T. J. Buchanan. *Proc. Instn Elect. Engrs, Pt III*, **99**, 61–5 (*March*, 1952).

A method has been developed for the measurement of the vector permittivity of water and other high-loss liquids. A description is given of apparatus which has been constructed for the purpose of making measurements on water and aqueous solutions at wavelengths of 3·2 cm and 1·26 cm. Measurements recorded with water at 3·2 cm and 1·26 cm are given and compared with the results obtained by Collie *et al.* [Abstr. 963 (1948)]. The accuracy at both wavelengths is better than $\pm$ 1% in both k' and k''. A modification of the method has been developed to permit measurements to be made on high- and low-loss liquids or solids. A.

537.228.1 : 534.232

Some experiments with barium titanate. *See Abstr.* 2535

537.228.1 : 537.226.2 : 621.315.612.4

2701. Electrical, in particular piezo-electric, properties of barium titanate. J. H. van Santen and G. H. Jonker. *Tijdschr. Ned. Radiogenoot.*, **16**, 259–76 (*Nov.*, 1951) *In Dutch.*

A survey of the electric properties of ceramic barium titanate. The piezo-electric properties are discussed and it is shown how the piezo-electricity of pre-polarized $BaTiO_3$ can be considered as a combination of a linearized electrostriction and a real piezo-electric effect. Some possible applications of $BaTiO_3$ ceramics are mentioned. A.

537.228.3 : 535.52

2702. The electro-optic effect in uniaxial crystals of the dihydrogen phosphate (XH_2PO_4) type. IV. Angular field of the electro-optic shutter. B. H. Billings. *J. Opt. Soc. Amer.*, **42**, 12–20 (*Jan.*, 1952).

When voltage is applied to a basal section of uniaxial crystal of the type XH_2PO_4, the crystal becomes biaxial. Between crossed polarizers it can be considered, then, to act as a light valve. The angular field of view is limited by the natural retardation of the crystal. This paper discusses methods by which this natural retardation can be minimized or effectively cancelled so that the retardation with no voltage is essentially zero over a large angular field. In the first method a basal section of uniaxial crystal of opposite sign is placed in series with the slab to be excited. Another technique uses two slabs of similar crystal with a 90-degree optical rotator placed between them. Both these techniques are treated theoretically and experimental measurements are given to show the resulting angular polarization pattern. This pattern is shown both for the electrically excited case and the unexcited case.

ELECTRIC CONDUCTION . CURRENTS 537.3

537.3 : 537.543 : 621.315.5 : 621.38

2703. Thermal and shot fluctuations in electrical conductors and vacuum tubes. S. S. SOLOMON. *J. Appl. Phys.*, **23**, 109–12 (*Jan.*, 1952).

A new derivation of Nyquist's equation, relative to the amount of thermal fluctuations generated in an electrical conductor, is presented. A generalization of the new proof to include any arbitrary impedance function shows that the original equation as derived by Nyquist is valid only for physically realizable impedances of the minimum reactance type. This is followed by a new and short derivation of the shot noise formula for temperature-limited diodes. A.

537.31 : 536.48 : 536.21

The thermal and electrical conductivity of copper at low temperatures. *See Abstr.* 2661

537.311.31

2704. Metallic conduction—the internal size effect. An addendum. D. K. C. MACDONALD. Letter in *Phil. Mag.*, **43**, 124–5 (*Jan.*, 1952).

Notes expanding some of the ideas put forward in Abstr. 7850 (1951). C. A. HOGARTH

537.311.33

2705. Measurements of the electrical conductivity of CdS crystals due to bombardment with electrons of medium energy. H. BENDA. *Ann. Phys.* [*Lpz.*] **9**, 413–22 (*No.* 8, 1951) *In German.*

The electron-bombardment-induced conductivity σ_b was investigated for 800–3 000 V electrons and a current stream of 0·001 to 10 μA. As for irradiation by light, σ_b is related to the intensity of irradiation by a simple power law whose exponent lies between 0·5 and 1. In the region examined a particular crystal always gave the same value of the exponent and in the latter experiments was independent of the energy of the electrons, incident current, and on the position of the incident beam relative to the evaporated electrodes. The variation of σ_b with voltage is complicated and seems to depend on the position of the electrodes. The quantum efficiency is less than for light radiation and can be quite different for crystals with the same dark- and photo-conductivity. The coefficient for secondary emission was roughly determined. C. A. HOGARTH

537.311.33

2706. Shot noise in germanium single crystals. G. B. HERZOG AND A. VAN DER ZIEL. Letter in *Phys. Rev.*, **84**, 1249–50 (*Dec.* 15, 1951).

Reports measurements on single "N"-type crystal filaments in the frequency range 1–1 600 kc/s. The noise ratio was well represented by the formula, $n = 1 + AI^2/f + BI^2/[1 + (f/f_0)^2]$, for $I = 3mA$, $AI^2 = 9{\cdot}3\times10^5$, $BI^2 = 54$, $f_0 = 1{\cdot}5\times10$ cycles/sec, and is independent of current. The third term is interpreted as the shot effect of the hole current. It is stressed that the values of the constants vary considerably from one sample to another and that such major departures from the f^{-1} law will not always be encountered. A. H. W. BECK

537.311.33 : 541.135

2707. Electric conductivity of silver sulfide. M. H. HEBB. *J. Chem. Phys.*, **20**, 185–9 (*Jan.*, 1952).

Mixed electronic and ionic conduction in Ag_2S is examined. The importance of terminal conditions which may affect the ratio of ionic to electronic currents in experimental measurements is emphasized. In particular, either the electronic or ionic components can be completely suppressed. This is the basis of a new method of measuring the ionic and electronic conductivities independently, as functions of the chemical potential ζ of the silver component. The electronic conductivity is found to vary as $\exp B\zeta$ both above and below the transition at 177°c. However, the coefficient B changes abruptly from e/kT below the transition to $e/2kT$ above. This result can be understood theoretically in terms of the following picture: Excess Ag is present mainly as dissolved atoms below the transition and as dissociated ions and electrons above. In the former case, only the electrons contribute to ζ, whereas in the latter there is a contribution both from the electrons and the ions. A.

537.311.33

2708. The electric conductance of liquid iron oxide. J. W. TOMLINSON AND H. INOUYE. Letter in *J. Chem. Phys.*, **20**, 193 (*Jan.*, 1952).

Measurements indicate a positive temperature coefficient of conductance, and a general behaviour as for a semiconducting solid non-stoichiometric oxide of the transition metals. The results of Fischer and Ende are probably in error. C. A. HOGARTH

537.311.33

2709. Theory of conductivity of semiconductors. G. JAFFÉ. *Phys. Rev.*, **85**, 354–63 (*Jan.* 15, 1952).

The author's older theory of conduction in polarizable media is generalized in such a way as to include rectification. An electronic component (positive holes or electrons) and an ionic component (negative or positive ions) are taken into account. The former are subjected to the boundary conditions of the Mott–Schottky theory, the latter to the boundary conditions of the author's theory of polarization. Significant deviations from the Mott–Schottky theory are caused by the ionic component. The fundamental equations are established in a general way and the boundary conditions are discussed. In the remainder of the paper only the limiting case is treated where all impurity centres are either completely associated or completely dissociated. The general procedure for treating the time-dependent equations is sketched, and the special case of simple a.c. is treated in detail. An expression for the current is obtained without the omission of any terms; however, its evaluation requires the introduction of a simplified "zero solution." The complete expression for the frequency dependence of the equivalent susceptance and conductance is established. The theory is compared with the results of a.c. measurements on locally manufactured Se disks; it explains the frequency dependence of capacitance and conductance over the range from about 2 000 to 200 000 c/s, if the presence of two species of ions of different mobilities is assumed. From this agreement ionic data, i.e. the concentrations of the carriers, their mobilities, diffusivities and the

thickness of the depletion layer, are derived and discussed. A.

537.311.33

2710. The effect of mercury on selenium. H. K. Henisch and E. W. Saker. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 149–54 (*Feb.*, 1952).

It is shown that the interaction between crystalline Se and liquid Hg or Hg vapour results in the formation of mercuric selenide. When produced in this form, this material is an excess semiconductor of high conductivity. The associated volume and surface diffusion have been investigated using radioactive Hg^{203}. Hg added to Se before the crystallization process results in material of high resistivity. This is ascribed to a reduction of the positive hole mobility. A.

537.311.33

2711. Impurity scattering in oxide semiconductors. E. W. J. Mitchell. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 154–61 (*Feb.*, 1952).

The oxide semiconductors are characterized by relatively high concentrations of impurity centres and low electron mobility. It is suggested that electron scattering by neutral impurity centres makes an important contribution to the resistivity of these materials. The familiar relation $\log \sigma_0 = \alpha + \beta\varepsilon$ together with the theory given by Busch are discussed and an alternative explanation involving impurity scattering and a dependence of ε on N is given. This is compared with experimental results for several oxides, including measurements by the author on the $Fe_2(Ti)O_3$ system. A.

537.311.33

2712. The effects of hydrostatic pressure on the ionic conductivity of AgBr. S. W. Kurnick. *J. Chem. Phys.*, **20**, 218–28 (*Feb.*, 1952).

Comparison of the conductivities of pure AgBr and AgBr doped with varying concentrations of $CdBr_2$ in the intrinsic temperature range determines the concentration of defects and the mobilities of silver vacancies and interstital ions. These quantities have been measured as a function of pressure up to 8 000 kg/cm² at three temperatures below 300°C. From the pressure variation of the defect concentration, the molar volume ΔV^* of the imperfections is found to be 16 cm³/mole below 300°C. An analysis of the pressure variation of the mobilities and of the Ag^+ interstitial ions and of the silver vacancies, respectively, indicates that the free volumes associated with their motions are 2·7 cm³/mole and 7·4 cm³/mole. The value of $\Delta V^* = 16$ cm³/mole is consistent with the Frenkel disorder type. At temperatures above 300°C, however, the observed value of $|\partial \ln \sigma/\partial p|$ is larger than expected from a simple Frenkel disorder type. An effort is made to interpret this behaviour in terms of mixed Frenkel and Shottky defects. A.

537.311.33 : 537.534.9

2713. Properties of ionic bombarded silicon. R. S. Ohl. *Bell Syst. Tech. J.*, **31**, 104–21 (*Jan.*, 1952).

Deals with a new technique by which the properties of Si surfaces are altered very materially by bombardment with ions of such gases as H, He, N and A. The change in rectifying properties has been of special interest but there have been considered also changes in the structural features of the material itself. The effects of bombardment on the rectifying properties are illustrated by a series of characteristic curves systematically arranged to bring out the effects of the several variables of experiment such, for example, as ion velocity, intensity of bombarding current, length of time of bombardment, kind of gas, and the temperature of the specimen during bombardment. The effect of bombardment on materials contaminated with impurities is also illustrated. It is of particular practical importance that Si contaminated with B to the point where it shows relatively little rectification can be modified by bombardment to make it even better than most unbombarded materials. A.

537.311.33 : 542.92

Conductivity of $LiAlH_4$ during decomposition. *See Abstr.* 3091

537.312.5

2714. On the question of noise in light-sensitive semiconductors. P. Görlich. *Optik*, **8**, 512–16 (*No.* 11, 1951) *In German.*

The noise is influenced by the structure of the semiconductor. Two new causes of noise have been traced, namely the barrier-layer noise and the crystal noise. From a quantitative point of view electrode noise is important as it is one of the major causes of noise and severely handicaps the application of the semiconductor for photometric measurements and direction finding. W. SUMMER

537.312.5 : 535.33.07–15

2715. Photoconductive cells for detection of infrared radiation. O. Simpson and G. B. B. M. Sutherland. *Science*, **115**, 1–4 (*Jan.* 4, 1952).

A review of the fundamental knowledge concerning i.r. sensitive cells of the Pb-compound type. Cooled cells are more sensitive but the threshold sensitivity of a PbS cell at peak λ deteriorates by a factor of 3 when cooling takes place from 273°K to 90°K, while the sensitivity threshold at 3·5 μ at the same time improves by a factor of approx. 7 500. PbS, PbSe, PbTe cells are used in industrial i.r. spectrometry with a resolving power of 30 000. In pyrometry, 100°C is the present lower limit of sensitivity. W. SUMMER

537.312.5 : 621.383.4

2716. A photovoltaic germanium cell. J. B. Rothlein. *Sylv. Techn.*, **4**, 86–8 (*Oct.*, 1951).

The electrical characteristics of photovoltaic cells under development are discussed. Factors affecting the speed of response and sensitivity are shown to be related to the lifetime of the hole-electron pairs created. The sensitive area of a point-contact cell was measured and shown to be about 5×10^{-3} cm². At room temperature, the resistance of the cells averaged 10 kΩ. The s./n. ratio can be very high since the cells are operated with no applied voltage, the only noise generated being the thermal noise of a 10 kΩ resistor. A.

537.312.6

2717. The influence of deviations from the Debye spectrum on the electrical conductivity of metals. F. H. J. Cornish and D. K. C. MacDonald. *Phil. Mag.*, **42**, 1406–10 (*Dec.*, 1951).

A more arbitrary form of vibrational spectrum is

examined for the calculation of metallic conduction as a function of temperature. The results for Li are in much better agreement with experiment in the range below 70°K than those calculated from Grüneisen's equation. C. A. HOGARTH

537.312.62

2718. Electron-vibration interactions and superconductivity. J. BARDEEN. *Rev. Mod. Phys.*, **23**, 261–70 (*July*, 1951).

Review of the author's and Fröhlich's theories and discussion of the criticisms by G. Wentzel, W. Kohn and Vachaspati, and S. D. Drell [Abstr. 7907, 7908, 8743 (1951)]. H. LONDON

537.312.62

2719. The magnetic threshold field curve of a superconductor. R. P. HUDSON. Letter in *Phys. Rev.*, **85**, 382 (*Jan.* 15, 1952).

Correction of some algebraic errors in Abstr. 979 (1950). H. LONDON

537.312.62

2720. The atomic heat of lead in the region of transition to superconductivity. J. R. CLEMENT AND E. H. QUINNELL. Letter in *Phys. Rev.*, **85**, 502–3 (*Feb.* 1, 1952).

First successful experimental confirmation for Pb of the Gorter–Casimir relation. A carbon-composition resistance thermometer was used. H. LONDON

537.312.67

2721. The change in electrical resistance of magnesium on melting. F. H. HORN. Letter in *Phys. Rev.*, **84**, 855–6 (*Nov.* 15, 1951).

The change in resistance has been measured for spectrographically pure and for commercial grades of the metal. The apparatus and experimental technique are briefly described. The results give values of the ratio of the resistivities of liquid and solid less than the value 2·1 calculated from the equation of Mott [*Proc. Roy. Soc.*, **146**, 465–72 (*Sept.* 1, 1934)] by about 25%. The temperature coefficient of resistivity of the molten metal is very small and sometimes negative. The resistivity starts to increase more rapidly than linearly at about 20° to 30° below the melting-point. M. R. HOPKINS

537.363 : 541.18

2722. Centrifugation potentials and the influence of electrolytes on the ζ-potential of As_2S_3 sol. G. JACOBS. *Meded. K. Vlaamse Acad. Wetensch.*, **13**, 28 *pp.* (*No.* 7, 1951) *In Flemish.*

The method of the centrifugation potentials has been used as a basis for the determination of the electrokinetic potential of colloidal solutions. The apparatus is described and an account of the most important results is given. The measured centrifugation potentials are proportional to ω^2. The influence of several electrolytes (KCl, Na_2SO_4, $K_4Fe(CN)_6$, Na_2S, HCl, $BaCl_2$, $\left[Co\begin{matrix}(NH_3)_5\\Cl\end{matrix}\right]Cl_2$, $\left[Co\begin{matrix}(NH_3)_4\\CO_3\end{matrix}\right]NO_3$) on the ζ-potential of concentrated As_2S_3 sol is studied by means of the present technique. A.

ELECTRIC DISCHARGES 537.52

537.521 : 538.561

2723. Low frequency disturbances in gaseous conductors. E. B. ARMSTRONG, K. G. EMELEUS AND T. R. NEILL. *Proc. Roy. Irish Acad. A*, **54**, 291–310 (*No.* 18, 1951).

The problem of obtaining steady discharges through low-pressure gaseous conductors has been examined by experimental and theoretical studies of plasma-ion waves, electrical noise, moving striations and anode spots. It is concluded that discharges can probably be obtained from which sustained low-frequency oscillations are absent, but that elimination of random disturbances may not be possible. Attention is called to the possibility that turbulent flow may occur, and that there may be coupling of mechanical and electrical vibrations in the gas. A.

537.521.6 : 538.12

2724. Theory of the discharge potential of coaxial cylindrical electrodes in a transverse magnetic field. G. VALLE. *Nuovo Cim.*, **9**, 145–68 (*Feb.*, 1952) *In Italian.*

The theory previously developed by the author [Abstr. 7260 (1950)] is extended to the case of coaxial cylindrical electrodes. For every particular geometry of the system of electrodes (characterized by the ratio ρ between interelectrode distance R and radius of the inner cylinder a) and for each value of $\overline{HR}$, the corresponding curve of Paschen $\overline{V} = F(\overline{pR})$ resulting is defined, $\overline{V}$, $\overline{pR}$, $\overline{HR}$ being standardized values, applying to every gas, of V, pR, HR, that is, respectively, of the discharge potential, the product of the interelectrode distance R times the pressure p, and the product of this distance times the intensity H of the magnetic field. When the dependence on X/p of the coefficient of the γ effect at the cathode is not considered and γ is given a constant intermediate value, the problem is, at least qualitatively, solved by these curves, which show, within certain limits, all four types of breakdown: ordinary far and near breakdown, magnetic far and near breakdown. The curves of Paschen can thus be used without discrimination only in the cases in which the inner cylinder (or wire) is a cathode. For the inverse polarity, as in G.M. counters, a limit is drawn by the fact that the magnetic field, in reaching a certain value, may annul the γ effect at the cathode, where in this case the electric field X has its lowest value. A.

537.523 : 538.67

2725. Self-magnetic fields in high current discharges. M. BLACKMAN. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 1039–45 (*Dec.*, 1951).

The theory of the self-magnetic field in high current discharges, originally developed by Tonks, has been investigated omitting a special assumption used in the work of Tonks. The influence of the parameters describing the discharge conditions has been considered in some detail. A comparison is also made with a simple, though more approximate, version of the theory due to Thonemann and Cowhig. The two theories are shown to be in good agreement. A.

537.523.4 : 778.37

The electrical and luminous characteristics of short air sparks suitable for high speed photography. *See Abstr.* 3194

537.523.5 : 537.527.5

2726. Temperature measurements in water [wall] stabilized heavily loaded arcs. F. BURHORN, H. MAECKER AND T. PETERS. *Z. Phys.*, **131**, 28–40 (*No.* 1, 1951) *In German.*

Discharge temperatures are deduced from a study of the radial variations of intensity for the lines H_β, O II (4 651 Å), and O III (3 447 Å) in water stabilized arcs with currents varying from about 50 to 1 450 Å. Temperatures range up to 50 000°K, and are related in the paper to current densities, etc. J. D. CRAGGS

537.523.5 : 621.315.618 : 621.3.015.5

2727. Observations on the electrical breakdown of gases at 2 800 Mc/s. II. Relative breakdown stresses, statistical lags and formative lags. W. A. PROWSE AND W. JASINSKI. *Instn Elect. Engrs Monogr. No.* 32, 11 *pp.* (*March* 15, 1952) [To be published also in *Proc. Instn Elect. Engrs, Pt IV*, **99**].

For Pt I, see Abstr. 9508 (1951). Gas confined in a nosed-in-cavity type of resonator is subjected to individual pulses of electric stress of frequency 2 800 Mc/s, and the variation of the field amplitude with time is recorded oscillographically. The study of the oscillograms deals with the statistical and formative time-lags preceding breakdown and with the relative breakdown stresses of various gases. In all experiments the gas in the resonator is irradiated by means of an auxiliary spark fired just before the beginning of the microwave pulse. The effect on the time-lags of the flux of radiation and, separately, of the distance between the irradiating spark and the resonator are examined. The formative time is found to be zero, within the limits of experimental error, for air, nitrogen, oxygen and hydrogen in all conditions examined. It is appreciable, however, in neon, argon and helium. The statistical time-lags are much greater in air and nitrogen than in oxygen and hydrogen. A study of these time-lags suggests that electrons are present in the gap throughout the pulse and that breakdown occurs as a consequence of a single event in the life of an electron, rather than by a progressive growth of ionization. The formative times in neon agree with the hypothesis that in this gas electrons are not removed during the pulse. A.

537.529 : 621.315.61 : 621.3.015.5

2728. Dielectric breakdown of solids. S. WHITEHEAD. *London, Oxford University Press* (1951) XV + 271 *pp.* Review in *Brit. J. Appl. Phys.*, **2**, 333–4 (*Nov.*, 1951).

X-RAYS 537.531

537.531

2729. Spectral energy distribution in X-ray beam as a function of wavelength. M. A. GREENFIELD, R. D. SPECHT, P. M. KRATZ AND K. HAND. *J. Opt. Soc. Amer.*, **42**, 6–11 (*Jan.*, 1952).

The method described consists of obtaining filtration data with suitable filter material, and analysing this data in terms of Laplace transforms. The desired distribution of energy is obtained in terms of a sum of inverse Laplace transforms. A.

537.531 : 535.33

2730. Influence of the applied potential on the satellites of the [X-ray] lines of gold, lead and bismuth. L. SALGUEIRO AND M. H. BLANC DE SOUSA. *Portugal Phys.*, **3**, 95–9 (*No.* 2, 1951) *In French.*

The satellites of the $L\beta_2$ disappear when the applied potential decreases below the ionization potential of the L_I-electrons, thereby confirming Coster and Kronig's theory on the origin of these satellite lines as due to atoms doubly ionized by an Auger transition within the *L*-shell. L. PINCHERLE

537.531 : 535.33

2731. Weak rays in the *K* X-ray emission spectra of the elements between Zn(30) and Kr(36). L. GROVEN AND J. MORLET. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 630–9 (*No.* 7, 1951) *In French.*

Zn, As, Se, Br and Kr were used at $\sim 0{\cdot}01$ mm Hg pressure and excited by damped h.f. oscillations at 70 kV. Many new weak lines were photographed with a curved mica crystal spectrograph. The four main groups of lines were of wavelengths respectively longer and shorter than each of the main $K\alpha$ and $K\beta$ lines. There were also a few lines of wavelength shorter than the principal absorption discontinuity. Theoretical interpretations are advanced.

S. T. HENDERSON

537.531 : 535.343

2732. X-ray absorption lines. I. B. BOROVSKIĬ AND V. I. RYDNIK. *Dokl. Akad. Nauk SSSR*, **80**, 41–4 (*No.* 1, 1951) *In Russian.*

Absorption lines are observed in the continuum near the absorption edge for certain transition elements. Their presence can be explained by the special electronic structure of the transition groups of which Mo^{42} and Sm^{62} are taken as examples. There are 2 close absorption maxima corresponding to Mo^{42} L_{III}–$N_{IV, V}$ and Sm^{62} M_V–$N_{VI, VII}$. The Dirac formula (which has been verified only for 1-electron X-ray spectra) for the fine structure gives only $\frac{1}{3}$ of the separation which is observed. This divergence can be attributed to incorrect values of σ the screening constant. σ_{4d} for Mo is observed to be 10 and σ_{4f} for Sm to be 19 as against 24 and 33 given by the classical theory. The screening constants are recalculated and bring doublet separation and relative intensity into agreement with observations. A. L. MACKAY

537.531 : 535.343

2733. The absorption of selenium in the soft X-ray region. M. P. GIVENS AND W. P. SIEGMUND. *Phys. Rev.*, **85**, 313–14 (*Jan.* 15, 1952).

The absorption of selenium (from 180 Å to 240 Å) has been investigated experimentally. The absorption edge near 225 Å has been resolved into a double edge due to M_{IV} and M_V absorption. The separation of these edges is 0·7 eV. A minimum in the absorption is observed at 208 Å. A.

537.531 : 537.533.8

2734. The experimental determination of the spectrum of a betatron. K. PHILLIPS. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 57–9 (*Jan.*, 1952).

By measuring the energy of photo-protons from

deuterium the X-ray spectrum of a betatron, of maximum energy 20 MeV, has been deduced. A small difference between the experimental determination and the theoretical curve in the 10 MeV region is found. A.

537.531 : 537.533.8

2735. The angular distribution of synchrotron target radiation. E. G. MUIRHEAD, B. M. SPICER AND H. LICHTBLAU. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 59–63 (*Jan.*, 1952).

Some measurements on the angular distribution of thin target radiation produced in a synchrotron are reported using ionization chambers to measure the X-ray intensity. Quantitative agreement has been obtained with the bremsstrahlung multiple-scattering theories of Schiff and Lawson for the case of a Pt target in the range of electron energies of 10–14 MeV. A.

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533 : 621.318.423 : 621.384.61

2736. A coil system for an air-cored betatron. R. LATHAM, M. J. PENTZ AND M. BLACKMAN. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 89–93 (*Feb.*, 1952).

Describes the design of an air-cored coil system for a small betatron and measurements of the field configuration produced by this system. A.

537.533 : 621.384.62

2737. The M.I.T. linear electron accelerator. P. T. DEMOS, A. F. KIP AND J. C. SLATER. *J. Appl. Phys.*, **23**, 53–65 (*Jan.*, 1952).

The M.I.T. linear electron accelerator consists of a circular waveguide fitted with uniformly spaced irises, and sustains a standing-wave, transverse magnetic π-mode oscillation at a resonant frequency of 2 800 Mc/s. The phase velocity is equal to the velocity of light. Electrons are injected into the accelerating tube at an energy of 2 MeV by a standard Van de Graaff generator. Acceleration up to an energy of at least 18 MeV has been obtained, using the 21 ft length of the accelerator. Peak accelerated currents of the order of 10 mA, and average currents of the order of 1 μA, are obtained. The accelerator is fed by 21 tunable magnetrons (Raytheon RK5586), phased in synchronism. In this paper, the principles of design, constructional features and operation are discussed. The accelerator is now being used for nuclear experimentation. A.

537.533 : 621.384.62

2738. Particle dynamics in the linear accelerator. J. R. TERRALL AND J. C. SLATER. *J. Appl. Phys.*, **23**, 66–77 (*Jan.*, 1952).

Hamilton's equations for the motion of an electron in a linear accelerator are integrated to find the final kinetic energy and phase of an electron injected with arbitrary initial kinetic energy and phase, after travelling down a fixed length of accelerator. The results are expressed in the form of a map of the initial energy-phase space on to a final energy-phase space. This map proves in practice to be very convenient for discussing the actual operation of the accelerator. The curves presented are calculated for numerical values appropriate for the M.I.T. accelerator. A.

537.533.72 : 621.385.833

2739. A theory of the electrostatic "einzellinse" with perturbed symmetry of revolution. E. REGENSTREIF. *Ann. Radioélectricité*, **6**, 244–67 (*July*, 1951) *In French.*

Deals with thin lenses with an elliptic central hole. The results for a perfect lens are reviewed before the field and ray equations for the elliptic lens are established. The ray equations are integrated for paraxial electrons and explicit formulae for the optical properties are deduced. A. H. W. BECK

537.533.72 : 621.385.833

2740. On a potential model useful in the study of the three electrode lens. M. BERNARD. *C.R. Acad. Sci.* [*Paris*] **233**, 1438–40 (*Dec.* 3, 1951) *In French.*

By assuming a bell-shaped field very simple expressions for the focal length and image plane are derived, which give results in good agreement with the more accurate expressions due to Regenstreif [Abstr. 8770 (1951)]. Two coefficients only have to be deduced from a curve giving the axial potential variation. A. H. W. BECK

537.533.72 : 621.385.833

2741. On the theory of third-order rays in independent electrostatic lenses. E. REGENSTREIF. *C.R. Acad. Sci.* [*Paris*] **233**, 1588–90 (*Dec.* 19, 1951) *In French.*

Following work [Abstr. 8770 (1951), 321 (1952)] establishing Gaussian and trans-Gaussian ray-paths, formulae are given for the third-order ray-paths. From these, an expression for the geometrical aberration is obtained which is more suitable for numerical calculation than that used hitherto. R. S. PEASE

537.533.72

2742. Perturbation characteristic functions and their application to electron optics. P. A. STURROCK. *Proc. Roy. Soc. A*, **210**, 269–89 (*Dec.* 20, 1951).

Attempts to systematize and extend to higher orders the aberration theory of electron optics. Hamilton's "equation of the characteristic function" is derived in the usual way from the variational equation for an unperturbed system. It is then assumed that the variational function, i.e. the integrand of the variational equation, depends on a "perturbation parameter" and the corresponding perturbations of Hamilton's point characteristic function and of Hamilton's differential relation are obtained. The first-order terms, when separated, lead to the introduction of a pair of characteristic functions whose arguments may be—among other choices—the co-ordinates in the object and aperture surfaces; from these one may obtain the perturbation of the ray throughout its length. The perturbation of rays at a surface which is an image surface of the unperturbed system may be derived from a single characteristic function. Formulae simplify considerably if the unperturbed system is Gaussian or otherwise orthogonal. It is found that there exist two distinct pairs of 2nd-order characteristic functions; this duality offers a means of checking 2nd-order calculations. Once again, perturbations at an image

surface may be evaluated from a single characteristic function. When calculations are taken beyond the first order, it is necessary to consider more than one parameter, since perturbation effects are then no longer additive. The theory is used to establish formulae for the geometrical, chromatic and mixed aberrations of two classes of systems; one contains all systems of rotational symmetry, the other all systems with curved axes. Certain transformations which may be applied to the perturbations of a variational function, the use of complex co-ordinates, and a classification of electron-optical systems according to their aberration calculations are treated in appendices. Although the theory is developed only to the 2nd order, the extension to higher orders is straightforward. A.

537.533.72 : 537.534.72 : 621.3.013 : 621.38

2743. Simulation of trajectories of charged particles in magnetic fields. G. H. VINEYARD. *J. Appl. Phys.*, **23**, 35–9 (*Jan.*, 1952).

A ball rolling on a rotating surface is shown to simulate the motion of a charged particle in a magnetic field. The theory is given for the case of a warped surface undergoing arbitrary rotation about a fixed axis and translation perpendicular thereto, while the system from which the ball is observed partakes of similar but independent motion. With approximations based on not too large departure of the surface from flatness, the following cases can be simulated: (*a*) The magnetic field is homogeneous and constant. The electric field is perpendicular to the magnetic field, and irrotational, but otherwise arbitrarily spatially dependent, and arbitrarily time-dependent within certain limits. (*b*) The magnetic field is homogeneous but arbitrarily time-dependent. The electric field is perpendicular to the magnetic field and may have a variety of space and time dependences, including a part which encircles the axis and has just the right magnitude to produce acceleration in a circular orbit as in the betatron. Results of rudimentary experiments are presented which indicate that the method is capable of good accuracy. A.

537.533.72 : 621.385.833

2744. Rigorous calculation of typical electrostatic electron lenses. W. GLASER AND H. ROBL. *Z. angew. Math. Phys.*, **2**, 444–69 (*Nov.*, 1951) *In German.*

Exact solutions of the differential equation of the trajectories of electrons close to the axis are given for potentials along the axis determined by rotationally symmetrical electrostatic fields; these potentials have a configuration analogous to those of cylindrical lenses. Expressions are derived for the most important optical characteristics of these lenses. A.

537.533.72 : 621.385.833

2745. Nullification of space-charge effects in a converging electron beam by a magnetic field. M. E. HINES. *Proc. Inst. Radio Engrs*, **40**, 61–4 (*Jan.*, 1952).

Presents the conditions necessary for maintaining a uniformly converging conical electron beam in the presence of space charge. It is an extension of the Brillouin focusing condition to conical flow, requiring a converging rather than a uniform magnetic field. In this type of electron flow, the diverging effects of space charge are balanced against magnetic reaction forces for reasonably small cone angles of convergence. Though the balance of forces is exact only for infinitesimal angles, it is reasonably accurate for cones of half-angle of 10 degrees. The minimum beam size will be limited only by the effects of thermal velocities, by gun aberrations and by the magnetic field obtainable. A.

537.533.72 : 621.385.833

2746. Numerical ray-tracing in electron lenses. J. C. BURFOOT. *Brit. J. Appl. Phys.*, **3**, 22–4 (*Jan.*, 1952).

For the solution of the paraxial ray equation, a very simple step-by-step method is given, using a procedure due to Fox and Goodwin for equations of the type $d^2y/dx^2 = f(x)y$. The accuracy of the method can be increased to any desired extent without increasing the complexity. All sources of inaccuracy except those present in the given field data can thus be avoided, and the aberration integrals can be accurately evaluated. If required, an approximate solution may be obtained initially, which is easily modified later for better accuracy, without redundancy of the early work. Graded intervals are easily introduced. A worked example is given for a strong electrostatic lens. A.

537.533.72 : 533.5 : 621.385.833

2747. A vacuum bench. H. BOERSCH. *Z. Phys.*, **130**, 517–20 (*No.* 4, 1951) *In German.*

Describes units of uniform cylindrical section, suitable for building up into vacuum apparatus. For example, using units such as observation windows, electron sources, electron lenses, etc., it can be used in electron optics. W. SUMMER

537.533.72 : 621.385.833

2748. Magnetic electron microscope projector lenses. G. LIEBMANN. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 94–108 (*Feb.*, 1952).

The results of an earlier paper [Abstr. 1851 (1952)] are extended to the special case of the electron microscope projector and similar type lenses. It is shown that the focal properties of symmetrical projector lenses with different ratios of gap width S to lens bore D can be represented by a single curve. This is then applied to the discussion of various cases of practical interest. The calculated results are found to be in excellent agreement with measurements by Ruska. The question of image distortion as a function of design parameters and lens excitation is then discussed; it is shown that all the types of lenses investigated can be operated at a point where they are free from "radial distortion." A consideration of scaling operations shows that there is little difference between the optimum performance of lenses of different geometry, but equal focal length. Certain results of use in practical lens design are combined in a design chart from which the relevant design or operational parameters can be read directly. In conclusion, design rules are given for the optimum design of projector lenses covering a wide range of magnifications. A.

537.533.73

2749. Some improvements to the electron [diffraction] analyser of Montreal University: I. Focusing with a magnetic lens. L. GRÉGOIRE AND M. ROUAULT. *Ann. Acfas*, **17**, 75–80 (1951) *In French.*

A lens for focusing the diffracted beams on to the

photographic plate is described. The lens secured the maximum definition compatible with the incident-beam collimation. R. S. PEASE

537.533.73

2750. Some improvements to the electron [diffraction] analyser of Montreal University: II. Microphotometer curves with rotation. R. BÉLAIR AND M. ROUAULT. *Ann. Acfas*, **17**, 80–3 (1951) *In French.*

Irregularities in the photometer curves of electron diffraction photographs were smoothed out by rotating the photographic plate about the pattern centre during the photometering. R. S. PEASE

537.533.75

2751. Energy per ion pair for electrons in gases and gas mixtures. J. M. VALENTINE. *Proc. Roy. Soc. A*, **211**, 75–85 (*Feb.* 7, 1952).

The energy expenditure per ion pair, V, for electrons in A, He, H, N, air, O and CH_4 is determined using ion chambers and proportional counters with terminals which correct for "end-effect." Experiments using A^{37} and T as sources of ionizing electrons are performed. Curves of ion current against percentage of A admixed with the other gases are plotted. The variation of V with energy of the ionizing electrons is investigated for N between the limits 200 eV and 46·7 keV for the primary electrons and only a small variation is found. The ratio V gas/V A is given in each case and is found to be almost identical to the corresponding ratio for ionization by 340 MeV protons. Examination of previous work with α-particles suggests close agreement with the values for electrons and protons. A.

537.533.8

2752. Secondary emission from composite surfaces. H. JACOBS, J. MARTIN AND F. BRAND. *Phys. Rev.*, **85**, 441–7 (*Feb.* 1, 1952).

A method was utilized of determining the secondary emission threshold energy for various composite surfaces. It was found that each compound had its own threshold energy value below which primaries would not yield true secondaries and above which primary electrons would cause the emission of secondary electrons. The experimental results were checked by means of two very different experimental structures. Comparisons were made of the electron energy necessary to remove an electron and these represent almost the same values as the energy necessary to remove an electron from the filled band to the vacuum when compared with optical experiments and with calculations. It was concluded that true secondaries originate from the filled band of the compound rather than from electron traps, as several authors previously supposed. In addition, it was found that the addition of Ag to Cs_2O did cause an increase in secondary emission yield, not due to traps, but because of the formation of a new filled band level, less deep than that of Cs_2O without the Ag additive. It was inferred that the action of the Ag was to form a new compound, more active as a secondary emitter than Cs_2O. A.

537.533.8 : 537.531

Experimental determination of the X-ray spectrum of a betatron. *See Abstr.* 2734

537.533.8 : 537.531

Angular distribution of synchrotron target radiation. *See Abstr.* 2735

537.534 : 621.317.324 : 621.384.62

2753. Determination of field strength in a linear accelerator cavity. L. C. MAIER, JR AND J. C. SLATER. *J. Appl. Phys.*, **23**, 78–83 (*Jan.*, 1952).

One theoretical and two experimental methods are described for finding the accelerating fields in the M.I.T. linear accelerator cavity, in terms of the input power. One of the experimental methods is based on measuring the power leaking out through a calibrated hole in an end wall closing the cavity, the hole being located where the field strength is to be determined. The other method is based on the perturbation of the resonant frequency of the cavity by a small conducting sphere located on the axis. All three methods of determination check satisfactorily. In terms of the resulting relations, the probable field actually existing in the accelerator under operating conditions is discussed. A.

537.534 : 621.384.61

2754. The regenerative deflector for synchro-cyclotrons. K. J. LE COUTEUR. *Proc. Phys. Soc. [Lond.] B*, **64**, 1073–84 (*Dec.*, 1951).

Tuck and Teng have proposed to extract the beam from a synchrocyclotron by modifying the normal magnetic field in such a way as to build up the amplitude of radial oscillations until protons can escape from the magnet. In the present paper the method is studied analytically and formulae are derived which express the performance in terms of the magnetic field perturbations: these formulae have been evaluated numerically in sufficient detail to guide practical design. A.

537.534.72

2755. Two-directional focusing with short uniform magnetic fields. C. REUTERSWÄRD. *Ark. Fys.*, **4**, 159–71 (*Paper* 3, 1951).

The 3-dimensional ion optic properties of the uniform magnetic fields with boundaries are investigated in the case of ion paths near the plane of symmetry, and the results are given in terms of the dioptrics of ion lenses. The conditions of simultaneous focusing of pencils of rays perpendicular and parallel to the lines of flux are stated in a somewhat specialized class of fields. The 2nd-order aberrations in planes parallel to the plane of symmetry are given. The existence of fields in which these cancel in points of the optic axis is pointed out. The same 2nd-order aberrations due to the fringing fields are calculated to the first approximation. A.

537.534.72

2756. On the first images obtained with a proton microscope. P. CHANSON AND C. MAGNAN. *C.R. Acad. Sci. [Paris]* **233**, 1436–8 (*Dec.* 3, 1951) *In French.*

Briefly describes the electrostatic lens system, proton source, fluorescent screen and other experimental details. A grid smoked with a benzene flame was used as test object, and a photograph claimed to be the first ever made with protons is shown. The resolving power was of the order 300 Å.

A. H. W. BECK

537.534.72

2757. On transmission ion-microscopy. M. GAUZIT. *C.R. Acad. Sci.* [*Paris*] **233**, 1586–8 (*Dec.* 19, 1951) *In French.*

A simple ion gun giving an intense fine beam of Li^+ ions, was fitted to an electrostatic electron microscope. Photographs of ZnO crystals obtained with 30 sec exposures at 12 500× show a resolution of about 200 Å. R. S. PEASE

537.534.72

2758. Recent developments in mass spectrometry. J. G. HUTTON AND T. E. USHER. *Gen. Elect. Rev.*, **54**, 18–23 (*Nov.*, 1951).

Describes the basic principles, development and applications in elementary terms. T. G. PICKAVANCE

537.534.72

2759. Correction in mass-spectrometric abundance measurements in consequence of the mass dependence of the electron-release by means of isotope ions. W. PLOCH AND W. WALCHER. Note in *Rev. Sci. Instrum.*, **22**, 1028 (*Dec.*, 1951).

The correction, which may sometimes reach 3·5%, depends upon the ion velocity and the state of the surface in the electron multiplier used for detection. A formula is given. T. G. PICKAVANCE

537.534.72

2760. Note on the superposition method in mass spectrometry. G. CARERI. *Nuovo Cim.*, **9**, 128–33 (*Feb.*, 1951) *In Italian.*

The molecular flow in a mass spectrometer is shown to be not the only condition to be fulfilled in order that the superposition method can be applied. The ionization, scattering and neutralization processes must also be considered, and simple rules for obtaining the right number of leaks, with the restraint of superposition, are worked out. A.

537.534.72 : 539.155.2

2761. Mass spectrometry. K. I. MAYNE. *Rep. Phys. Soc. Progr. Phys.*, **15**, 24–48 (1952).

This report describes the recent progress in mass spectrometer design and applications. Improvements in the conventional single-focusing mass spectrometer, which have made possible the quantitative analysis of very small samples (as small as 10^{-15} g in some cases) with high precision, have been mainly in respect of increased resolving power by suitably shaping the magnetic deflecting field boundary (either symmetrically or asymmetrically) in order to obtain a significant third-order focusing effect in the source aperture angle, and of a greatly increased signal-noise ratio in the ion beam detector, by employing new devices, viz. the vibrating reed electrometer and the secondary electron multiplier. Double-focusing mass spectrographs are not discussed. The sensitivity of the mass spectrometer is now such that small changes in isotopic abundance, involving as few as 10^7 nuclei in some cases, can be detected. Nuclear processes (neutron absorption, radioactive decay, branching, fission) producing a significant isotopic composition change have been studied, employing specialist techniques. The very small fractionations, due to the differing thermodynamical properties of the isotopes, which can now be measured have important geochemical implications; by this means also a paleotemperature scale has been established. (Bibl. 73 items.) A.

537.534.74

2762. Mean-value calculations for projected multiple scattering. W. T. SCOTT. *Phys. Rev.*, **85**, 245–8 (*Jan.* 15, 1952).

The multiple-scattering theories of Molière and Snyder–Scott are compared, and the equivalence of the mathematical development stated. Using the preferable single-scattering probability of the Molière theory, results are quoted of interest to experimenters. Several mean-value quantities are given: mean arithmetic angle, median angle, half-width, $1/e$ width, angle $1/P_0\pi^{\frac{1}{2}}$ related to the zero-angle amplitude, and mean arithmetic angle with a cut-off at 4 times the mean. These quantities are given for both the projected tangent angle and projected chord angle distributions, in the form of linear relationships between the square of the angle divided by Ω and the logarithm of Ω, where Ω is the mean number of scatterings undergone by the particle in question. The linear relationships are good to 1% for Ω from 10^2 to 10^5. Information is also given on smoothed-out distributions, and on an estimate of the error for the cut-off arithmetic mean angle. The scattering constant K is given for several methods of measurement, for Ilford G-5 emulsions. A.

537.534.74

2763. Proton-proton scattering at 240 MeV by a magnetic deflection method. O. A. TOWLER, JR. Letter in *Phys. Rev.*, **84**, 1262–3 (*Dec.* 15, 1951).

Protons scattered by a polyethylene target in a cyclotron were detected with photographic plates. The incident angle at the plates was measured with a microscope. The cross-section increased sharply at 8·7° (centre of mass). Excluding this, the average value was 4·66 ± 0·39 mb/sterad. F. R. HOLT

537.534.74

2764. Proton-proton scattering at 240 MeV. C. L. OXLEY AND R. D. SCHAMBERGER. *Phys. Rev.*, **85**, 416–23 (*Feb.* 1, 1952).

Differential proton-proton scattering cross-sections have been measured at 6 angles in the range from 27 to 90 degrees centre of mass. The internal undeflected cyclotron beam was used with a hydrocarbon target. Proton-proton scattering was differentiated by detecting the emitted proton pair with its definite angle between particles in coincidence with two scintillation counters. Scintillator dimensions determined the solid angle accepted. The incident beam was monitored by measurement of the β-activity induced by the reaction $C^{12}(p, pn)C^{11}$ in the target. General cyclotron background was negligible. The cross-sections measured show isotropy in the centre of mass system within estimated errors. The average value of the cross-section was 4·97 ± 0·43 millibarns/steradian based on a 49 ± 3 millibarn C cross-section. This is in poor agreement with previous measurements of 3·6 ± 0·3 mb/steradian. A.

537.534.74

2765. High energy elastic proton-deuteron scattering. G. F. CHEW. Letter in *Phys. Rev.*, **84**, 1057–8 (*Dec.* 1, 1951).

The 3-body case is analysed theoretically using the

impulse approximation and known n–p and p–p data. Results agree satisfactorily with recent experiments [e.g. Abstr. 340 (1952)]. F. R. HOLT

537.534.74 : 530.145 : 539.185

The analysis of high energy neutron-proton and proton-proton scattering data. *See Abstr.* 3014

537.534.74 : 539.132

The scattering of atoms from diatomic molecules. *See Abstr.* 2869

537.534.74 : 539.132

On the scattering of H_2^+ by H_2. *See Abstr.* 2870

537.534.74 : 539.164.7

Scattering of α-particles by α's and helium. *See Abstr.* 2950–1

537.534.74 : 539.172.4

2766. The scattering of neutrons and of protons by deuterons. R. A. BUCKINGHAM, S. J. HUBBARD AND H. S. W. MASSEY. *Proc. Roy. Soc. A*, **211**, 183–204 (*Feb.* 21, 1952).

The theoretical treatment of neutron-deuteron collisions in an earlier paper [Abstr. 2721 (1941)] is here extended to include neutrons with energy up to 16 MeV, and also collisions between deuterons and protons with incident energy up to 11·5 MeV. Previous results are also modified by the inclusion of effects arising from a relative angular momentum $\sqrt{6}\hbar$ (d scattering). A detailed comparison is made with experimental evidence for the total elastic cross-section for n–d collisions, and for the angular distribution of protons and neutrons scattered by deuterons. Within the accuracy of measurement the evidence is consistent with charge independence of the nuclear forces at the energies concerned; the comparison with calculated results appears strongly to favour forces of the symmetrical exchange type (or some similar exchange type) as against ordinary forces. Iterative methods of solving numerically the integro-differential equations arising in this kind of problem are discussed in an appendix. A.

537.534.74 : 539.185

Polarization effects in n–p scattering. *See Abstr.* 3012–13

537.534.75

2767. Range-energy relations. A. E. TAYLOR. *Rep. Phys. Soc. Progr. Phys.*, **15**, 49–67 (1952).

Recent work has allowed the establishment of a more accurate range-energy relation for α-particles and protons below 5 MeV α-particle energy. Measurements of the stopping power of a number of elements for protons of energies greater than 100 MeV have shown a linear relation between the mean excitation potential and the atomic number for elements of atomic number greater than that of Fe. Whereas the range-energy relation for α-particles and protons with energies greater than 20 keV can be interpreted by quantum-mechanical models of the atom, the results for very slow protons and for heavy ions and fission fragments can be interpreted by classical mechanics. Effects due to the polarization of the medium are noticed in the stopping of high-energy particles in all condensed matter and also of low-energy particles in metals. (Bibl. 103 items.) A.

537.534.75

2768. Range-energy relations for protons in Ilford C2 dry emulsion. F. A. EL-BEDEWI. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1079–83 (*Dec.*, 1951).

The range-energy relationship for protons of energies up to 12 MeV in Ilford C2 dry emulsion has been determined with an accuracy better than 0·5% in energy. The particles were produced by bombarding a thin Be foil with deuterons having an energy of 8 MeV. The energy of the incident deuterons was obtained by a method which involves the measurement of the two angles of emission at which the two proton groups of longest range from the reaction $Be^9(d, p)Be^{10}$ have the same energy. A.

DISCHARGE TUBES . COUNTERS 537.54

537.54 : 621.3.014 : 621.384.62

2769. Currents in a high-voltage ion accelerator tube. E. K. INALL. *Proc. Phys. Soc.* [*Lond.*] *B*, **64**, 1068–73 (*Dec.*, 1951).

It is well known that a large electron current passes through a vacuum tube when used for the electrostatic acceleration of positive ions. This paper deals with experiments which show that many of the electrons are produced by neutral particles bombarding the lower end of the tube. The particles are formed in the region of the ion source canal and have a low energy due to the extraction potential. It has been found possible to suppress all the electrons produced below the bottom of the accelerator tube. A.

537.542 : 621.318.572 : 621.387.42

2770. Tripartite instrumentation conference—1951. D. TAYLOR. *Nucleonics*, **9**, 5–12 (*Dec.*, 1951).

A summary of discussions between American, British and Canadian representatives at a conference held in May, 1951. Recent developments in counting rate meters, low background α-counters, cold-cathode scaling tubes, millimicrosecond coincidence and fast scaling techniques, automatic counting equipment kicksorters and light monitoring apparatus are described. L. R. SHEPHERD

537.542

2771. On the statistical analysis of the results of measurements carried out with Geiger counters. L. MEZZETTI AND R. QUERZOLI. *Nuovo Cim.*, **8**, 768–73 (*Oct.*, 1951) *In Italian.*

A formula giving the probability that a shower of N particles discharges ν out of n counters is derived. A.

537.542

2772. On the reliability of Geiger-counter response at moderately high rates. L. G. PARRATT AND C. F. HEMPSTEAD. Letter in *J. Appl. Phys.*, **22**, 1502–3 (*Dec.*, 1951).

The ratio of spurious to valid counts depends on counting rate, length of the discharge (e.g. whether the anode is beaded), immediate past counting history, tube age and overvoltage. The effect is serious at high counting rates. F. R. HOLT

537.542

2773. Xenon-filled Geiger counters. G. Barrère. *C.R. Acad. Sci.* [*Paris*] **233**, 1442–4 (*Dec.* 3, 1951) *In French.*

Gives a brief account of experiments with various quenching gases added to Xe in Geiger counters. Pure ether was found to be satisfactory. A typical plateau curve is shown. J. D. CRAGGS

537.542

2774. Plain and beaded wire Geiger counters for X-rays. L. G. Parratt, C. F. Hempstead and E. L. Jossem. *Rev. Sci. Instrum.*, **23**, 1–7 (*Jan.*, 1952).

The calibrations of typical self-quenching plain and beaded wire Geiger counters are studied for measurements of X-ray relative intensities over a range of 1 to 10^5 counts per sec. For plain wire counters, correction for "lost counts" in terms of resolving time is found to be unreliable except at rates less than about 100 counts per sec. The basic difficulty lies in a large and inconstant ratio of spurious to valid counts. This ratio depends upon counting rate, changes in counting rate, tube age, overvoltage and spread of discharge. Beaded wire counters are studied as an improved type of counter for incident-ionizing events whose primary ionization does not extend along a large fraction of the length of the anode wire. For beaded wire counters, it is believed that corrections reliable to about 2% can be made to the observed counting rate over a rate range of about one to a thousand counts per sec if the rate is not abruptly changed at rates above about 100 counts per sec. A.

537.542

2775. Some aspects of fission counter design. W. Baer and O. F. Swift. Note in *Rev. Sci. Instrum.*, **23**, 55–6 (*Jan.*, 1952).

An investigation of the effect of varying the thickness of a U_3O_8 layer in a flat-plate counter, for various inter-electrode spacings. Coatings as great as 2·0 mgm/cm² may be used, with a spacing of 0·150 in. J. D. CRAGGS

537.542

2776. Design of direction counters for clinical use. B. D. Corbett and A. J. Honour. *Nucleonics*, **9**, 43–59 (*Nov.*, 1951).

A directional counter for clinical use with I^{131} is described. The design is based on the use of a small G.M. γ-counter with a cylindrical cathode enclosed in a lead shield with an annular collimator which allows radiation from a limited active area to fall on the sensitive region of the counter. The response characteristics of the counter are discussed.

L. R. SHEPHERD

537.542

2777. Effect of hydrogen sulphide on the plateau of a Geiger–Müller counter. S. Ignatowicz and R. D. Phillips. Letter in *Research* [*Lond.*] **4**, 533 (*Nov.*, 1951).

Tests were made preparatory to using H_2S for gas-counting S^{35}. H_2S below 1 cm Hg mixed with (argon/10% Et formate) filling at 10 cm shortened the plateau slightly but did not appreciably steepen it.

537.542

2778. Fatigue effects in scintillation counters. L. Reiffel, C. A. Stone and A. R. Brauner. *Nucleonics*, **9**, 13–15 (*Dec.*, 1951).

Experiments showing the decrease in sensitivity with time, of photomultipliers used at very high counting rates are described. Measurements were made with a 1·04 Mc/s Co^{60} source, NaI(Tl) phosphor and RCA 5819 photomultiplier. With the discriminator set at 40%–70% of maximum pulse height and mean multiplier anode currents ranging from 7×10^{-7} A to $2{\cdot}25\times10^{-6}$ A, counting rates were observed to fall by more than 10% over periods of 10–70 min. It is recommended that the total anode current should not exceed 10^{-7} A for stable running. This may be done by reducing the accelerating voltage on the last 3 or 4 dynodes. L. R. SHEPHERD

537.542 : 539.166

Scintillation gamma ray spectrometer. *See Abstr.* 2962–3

537.542

2779. A new type of α-particle bench monitor. R. D. Connor. *J. Sci. Instrum.*, **29**, 12–13 (*Jan.*, 1952).

The development of a Rosenblum type of spark counter as a bench monitor for α-particles is described. Twenty-two such counters are arranged in parallel and the overall efficiency is found to be about 22%. The monitor exhibits a plateau of length about 250 V with a slope of 0·06%/V or better. The background counting rate is usually about 2 counts/min. The properties of this instrument are compared with those of previously reported air counters whose mode of action differs from that of the present counter. A.

537.542 : 539.16.08

2780. A new automatic radioassayer. S. J. Harris and A. Del Duca. *Nucleonics*, **9**, 60–4 (*Nov.*, 1951).

The device automatically moves samples from a stack into position below an end-window β-counter and restacks them after a sample count. The counting circuit incorporates an integrating ratemeter in which the total number of pulses recorded in a given sample count appears as a voltage across a condenser.

L. R. SHEPHERD

537.542 : 621.318.572

2781. Calculation of the counting loss of dividers according to the theory of Jost. E. Baldinger and K. Halbach. *Helv. Phys. Acta*, **24**, 315–17 (*No.* 4, 1951) *In German.*

A practical counting scheme is considered as a combination of an amplifier, an ideal counter, and two counters with normal characteristics. The amplifier (or "counter of the first kind") is supposed inoperative for a definite time upon the arrival of an event, the counters (or "counters of the second kind") are supposed to be blocked for another definite time after counting an event. Using Jost's formula [Abstr. 2003 (1947)] the counting losses are calculated for the case where the contribution of the amplifier to the losses is negligible. For numerical evaluation the series expansion of the ratio of the incomplete to the complete γ-function is found convenient. The results presented may be used to determine after what number of "good" stages one can change over

to low-performance counters with reduced discrimination for a given overall loss. S. C. DUNN (R)

537.542 : 621.318.572

2782. Decade scaling circuits. W. C. ELMORE. Note in *Rev. Sci. Instrum.*, **22**, 835–6 (*Nov.*, 1951).

All the methods discussed utilize 4 Eccles–Jordan trigger circuits and are modifications of the (4-stage) binary scale-of-16. (*a*) One feedback pulse may be generated and fed to the 2nd stage and one to the 3rd. (*b*) Binary counts may proceed to the count of 9, the 10th pulse resetting stage 4, with the normal triggering of stage 2 blocked. (*c*) A scale-of-8 may be blocked at the 2nd stage once in each cycle by a separate, 4th, flip-flop. (*d*) Binary counts may proceed to the count of 5, the 6th pulse resetting stage 3, with stage 4 normally triggered; at the 10th count this occurs again, with stage 2 blocked. (*c*) and (*d*) are claimed as new. A. J. KENNEDY (R)

537.542 : 621.318.572

2783. An improved quench circuit for parallel-plate counters. D. E. HUDSON. Note in *Rev. Sci. Instrum.*, **22**, 850 (*Nov.*, 1951).

Each pulse from the counter triggers a univibrator circuit which effectively cuts off, for the quench period, the valve through which h.t. is applied to the counter; circuit values are given. A. J. KENNEDY (R)

537.542 : 621.318.572

2784. A pulse-height distribution analyzer. W. E. GLENN. *Nucleonics*, **9**, 24–8 (*Dec.*, 1951).

The pulses to be measured are shaped (to give flat tops) and applied to the deflector plates of a special cathode-ray tube, containing a series of ten collector plates in place of the usual fluorescent screen. This device acts as a differential discriminator. The beam current is gated, so that it is on only at the top of the pulse and current consequently passes only to the top plate reached by the deflected beam. Methods for extending the number of channels to multiples of ten are described. Particulars of auxiliary circuits employed in pulse analysers utilizing these tubes are outlined. L. R. SHEPHERD

537.542 : 621.396.645.018.75

2785. A flexible pulse amplifier with good overload properties. R. L. CHASE AND W. A. HIGINBOTHAM. *Rev. Sci. Instrum.*, **23**, 34–6 (*Jan.*, 1952).

A general purpose linear pulse amplifier with good stability, short rise time and good overload characteristics is described. The basic circuit consists of two long-tailed pairs in a negative feedback loop containing a small amount of positive feedback inside the loop. A.

537.542 : 621.318.572

2786. On the resolution of short time intervals with scintillation counters. S. DE BENEDETTI AND H. J. RICHINGS. *Rev. Sci. Instrum.*, **23**, 37–9 (*Jan.*, 1952).

A simple coincidence circuit of resolving time of the order of 10^{-9} sec is described. Performance tests showed that, when the pulse-height distribution is constant during an experiment, this circuit can resolve time differences of the order of 10^{-10} sec. A.

537.543 : 621.385.833

2787. The current division control of electron streams. E. GUNDERT. *Telefunken Ztg*, **24**, 223–36 (*Dec.*, 1951) *In German.*

Investigates electron paths in a system consisting of a negative control grid between two positive electrodes (mixer tubes, etc.). Limiting trajectories, outside which the electrons perform "pendulum" oscillations, were determined and the grid characteristics were calculated for various assumed forms of the distribution of injected current over the possible angles of entry. A higher approximation introduces the effect of different fields on either side of the grid. A. H. W. BECK (R)

537.543 : 621.397.6 : 621.385.832

2788. The modulation characteristic of cathode-ray tubes in television. R. B. MACKENZIE. *Brit. J. Appl. Phys.*, **3**, 54–8 (*Feb.*, 1952).

The ambiguity which arises in defining the modulation characteristic of a television c.r.t. in terms of gamma is discussed. A method of eliminating this ambiguity is proposed, which is partly empirical, but leads to a simple mathematical treatment. Theoretical and actual characteristics for two different types of tube are compared; the effect of stray light and the variation with luminance of the sensitivity of the human eye are discussed. It is shown that, taking these factors into account, the error arising from the use of values derived by the proposed theoretical treatment instead of actual measured values is likely to be insignificant for many purposes. For greater precision, an extension of the system of definitions is suggested. A.

IONIZATION . THERMIONICS 537.56/.58

537.56 : 536.46 : 541.126

2789. Studies on the ionization produced by metallic salts in flames. III. Ionic equilibria in hydrogen/air flames containing alkali metal salts. H. SMITH AND T. M. SUGDEN. *Proc. Roy. Soc. A*, **211**, 31–58 (*Feb.* 7, 1952).

For Pt II, see Abstr. 7331 (1950). An examination has been made of the electron concentration produced when alkali metal salts are added to various hydrogen/air flames containing excess hydrogen. The results have shown that although the variation of the measured electron concentration with the concentration of added alkali metal shows the thermodynamically predicted behaviour, the variation with respect to flame temperature and ionization potential of alkali metal is very different from that predicted by theory. Coupled with this, there is a serious discrepancy between the measured and predicted levels of electron concentration, the former being much too low. The electron concentrations were measured by the attenuation of centimetric radio waves by the flame, and the temperatures by the sodium *D*-line reversal method. An explanation of some of the observed discrepancies is given. An experimental method has been devised for the estimation of the atomic and molecular ions (other than electrons) in flames by making the flame form a portion of the dielectric of a simple parallel-plate condenser. From the observations made the presence of such massive ions in these flames was inferred. An important preliminary step was to ensure that the concentrations of electrons which could be deduced from both the attenuation and capacity

methods were in agreement. It was obtained when flames uniform in cross-sectional temps. were used, entrainment of air with production of temperature inhomogeneity being prevented by sheathing the flame with a stream of nitrogen. Analysis of the heavier ion concentrations from the results indicated in general about twenty times as many as there were electrons. These were divided, to give charge balance, between positive alkali metal ions and OH^-, these being the only reasonable ionic species for these flames. Incorporation of this hydroxyl ion effect largely removes the discrepancy between the measured and predicted absolute electron concentration. The results lead to a reasonable value of the collision frequency of a heavy ion with molecules, and, combined with the theoretical hydroxyl concentrations for the flame, suggest a value for the electron affinity of hydroxyl of 62 ± 6 kcal/mole. A.

537.56 : 536.46 : 541.126

2790. Studies on the ionization produced by metallic salts in flames. IV. The stability of gaseous alkali hydroxides in flames. H. SMITH AND T. M. SUGDEN. *Proc. Roy. Soc. A*, **211**, 58–74 (*Feb.* 7, 1952).

The electron concentration produced by the addition of alkali metal salts to a wide range of hydrogen/air flames extending to the air-rich side of stoichiometric composition has been measured by the method of attenuation of centimetric radiowaves. Considerable deviations from the predicted behaviour on the basis of the known ionization potentials of the metals and the measured temperatures have been observed. The main effect noted is that for two flames of the same temperature, but on opposite sides of stoichiometric composition, the air-rich one always shows a markedly lower attenuation, an effect which is by far the most pronounced in the case of Cs. The electron concentration throughout is considerably below the predicted level. Simple statistical calculations have shown that the formation of gaseous ion pair molecules of the alkali hydroxides by combination with the hydroxyl radicals in the flame is plausible, and an analysis of the electron concentrations on this basis has shown that the results are compatible with removal of a large amount of Cs as hydroxide, but not of K and Na. This agrees with the expected difference in energy of formation of Cs and K hydroxides, from the gaseous metal and hydroxyl, of about 5 kcal/mole. It has not proved possible to explain the whole of the deviations of the electron concentration in this way, but by incorporation of a further effect, of production of hydroxyl ions, which is independent of the metal added, a complete resolution may be obtained. The hydroxyl radical concentrations implied by this analysis show excellent agreement with those obtained from thermodynamic calculation of the burned gas composition at equilibrium. Values for the heat of formation of gaseous potassium hydroxide and gaseous caesium hydroxide, from the gaseous metal and hydroxyl, which the data require are 87·5 ± 3 and 92·5 ± 3 kcal/mole respectively. The analysis of the results further implies an electron affinity for gaseous OH of 69 ± 5 kcal/mole, which agrees reasonably with the value obtained previously from flame measurements of 62 ± 6 kcal/mole. A.

537.56 : 539.132

2791. Dissociation of hydrogen molecules by vibrational excitation and three-body recombination coefficient. II. E. BAUER. *Phys. Rev.*, **85**, 277–80 (*Jan.* 15, 1952).

For Pt I, see Abstr. 359 (1952). The recombination of two H atoms in the presence of a third in a thermal collision is considered, the principle of detailed balance being used to obtain the three-body coefficient C_3 from the cross-section σ_2 of the reverse, dissociation process. This cross-section is calculated by a method developed previously which depends on correcting the Born approximation by means of the exact one-dimensional problem. The case is considered when the molecule is formed in a highly excited vibrational state of the electronic ground state and the excess energy of several kT goes into translational energy of the third atom. The three-body coefficient in this case is of order 3×10^{-36} cm^6 sec^{-1}, which is still much smaller than the empirical values. Some estimate is made of the validity of the correction method. The excitation and de-excitation of the first vibrational state of H by collisions with protons is investigated, and it is found that an excited molecule requires 10^3 to 10^4 thermal collisions to lose its excitation; this is roughly of the correct order of magnitude for such processes. A.

537.56 : 539.18

2792. The determination of the ionizing power of particles with masses intermediate between the meson and proton masses. V. KHARITONOV, G. MARIKYAN AND A. ALIKHANYAN. *Dokl. Akad. Nauk, SSSR*, **80**, 201–4 (*No.* 2, 1951) *In Russian.*

This was done by means of an argon-methane proportional counter. Momentum and range were determined using a new spectrometer [Abstr. 2803 (1952)]. The mass values deduced from the 3 groups of data are mutually consistent and scatter around 600 and 950 electron masses. W. J. SWIATECKI

537.56 : 551.510.535

Collision frequency of electrons in the ionosphere. *See Abstr.* 3142

537.563 : 542.95

2793. Relative isotope effects of C^{13} and C^{14}. W. H. STEVENS, J. M. PEPPER AND M. LOUNSBURY. Letter in *J. Chem. Phys.*, **20**, 192 (*Jan.*, 1952).

The decarboxylation of C^{14}-labelled mesitoric acid was studied with a mass-spectrometer. The C^{14} effect appears to be greater than twice the C^{13} effect. T. G. PICKAVANCE

537.564

2794. Ions of mass 19 from water. F. J. NORTON. Letter in *Phys. Rev.*, **85**, 154 (*Jan.* 1, 1952).

Reports the formation of H_3O^+ ions in a mass spectrometer, in the presence of water and excess H_2. The shape of the ionization probability function suggests that excitation is followed by ionization of a complex on second impact. T. G. PICKAVANCE

537.564

2795. Mass-spectrographic study of ionic reactions in hydrogen. R. L. MURRAY. *J. Appl. Phys.*, **23**, 6–11 (*Jan.*, 1952).

An analysis of the ratios of the di- and tri-atomic ions of hydrogen, deuterium, and H–D mixtures

obtained from a hot-cathode arc discharge in a magnetic field was used to examine the nature of ionic collision and displacement processes. Ion mobility, and consequently the rate of ion-molecule collisions, at constant pressure, was controlled by varying the intensity of the magnetic field. Statistical treatment of mass spectrograph data indicates that the formation of H_3^+ is due to the reaction $H_2^+ + H_2 \rightarrow H_3^+ + H$, and that the ion rather than the molecule undergoes dissociation on collision. A.

537.564

2796. Negative ion formation in oxygen. R. Geballe and M. A. Harrison. Letter in *Phys. Rev.*, **85**, 372–3 (*Jan.* 15, 1952).

Measurements of Townsend's α in oxygen below $X/p \simeq 40$ V/cm/mm show falling values of ionization current from which, if the effect is assumed to be due to electron capture, attachment cross-sections (σ), as a function of X/p or of mean electron energy, may be deduced. The comparison with previously published work on σ is made. J. D. CRAGGS

537.565

2797. Drift velocity of electrons in argon. L. Colli and U. Facchini. *Rev. Sci. Instrum.*, **23**, 39–42 (*Jan.*, 1952).

Drift velocity of electrons in pure A and in A–N mixtures has been measured with a parallel plate ionization chamber. A was purified by a Ca–Mg filled convection current purifier. Results for pure A agree with those of Nielsen. Sensitivity of drift velocity against A purity was investigated by adding to A small amounts of N. The purifier's efficiency in regard to the most common impurities contained in tank A was tested by absorption of given fractions of these impurities previously added to pure A. A.

537.583

2798. Spectral dependence of thermionic emission from (Ba–Sr)O cathodes over the visible region. T. Hibi and K. Ishikawa. Letter in *Phys. Rev.*, **84**, 1252 (*Dec.* 15, 1951).

The thermionic emission was measured during illumination from a switched monochromatic light source. After a rapid increase, due to the external photoeffect, the emission slowly increases over a period of more than 10 min. The spectral distribution showed peaks at 460 mμ, 500 mμ and 570 mμ. The results confirm the existence of several donor levels between the filled and conduction bands. A. H. W. BECK

537.583

2799. The emission from oxide-coated cathodes in an accelerating field. D. A. Wright and J. Woods. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 134–48 (*Feb.*, 1952).

It is shown that the steep rise of current with accelerating field in a diode with an oxide-coated cathode cannot be fully explained either by surface roughness or by patch effect. This leads to a theoretical treatment, based on the existence of a space-charge zone immediately inside the coating. The charge in this zone is shown to vary with applied field and with current density, and with certain coating parameters. The variation in the charge leads to a variation in work function, and thereby to a dependence of emission on field strength, which is to be combined with the normal Schottky effect. The effects of partial space charge on the relationship between field and anode voltage are discussed, and the diode characteristics of oxide cathodes can then be calculated for accelerating fields as a function of the coating parameters. The results are shown to be in agreement with experiment, and to confirm values of coating conductivity, electron density and mobility as determined directly by conductivity and Hall effect measurements. A.

537.583 : 621.385.833

2800. Characteristics of the hot cathode electron microscope gun. M. E. Haine and P. A. Einstein. *Brit. J. Appl. Phys.*, **3**, 40–6 (*Feb.*, 1952).

Experiments have been carried out on hot cathode, high-voltage, three-electrode, electron guns. The brightness has been measured and found under optimum operating conditions to approach closely the value expected from the theoretical considerations developed by Langmuir. The effect of varying geometry over a fairly wide range is shown to be of secondary importance, except in as far as it influences the bias conditions and current efficiency. The mechanism of electron beam formation is discussed briefly. A.

537.585

2801. The production of halogen negative ions at the surface of a thoriated tungsten filament. J. W. Trischka, D. T. F. Marple and A. White. Letter in *Phys. Rev.*, **85**, 136–7 (*Jan.* 1, 1951).

Yields of halogen negative ions have been measured by directing molecular beams of Cs halides at a thoriated W filament. The yield was constant over the temperature range 12 000–15 000°K. Yields are lower than calculated values but show the theoretical trend, except in the case of CsF. A. H. W. BECK

537.585

2802. Effect of various gases on potassium ion emission from hot platinum. E. L. Brady and P. D. Zemany. *J. Chem. Phys.*, **20**, 294–7 (*Feb.*, 1952).

The effect of several gases on the emission of K ions from a hot Pt surface has been studied. It has been found that O, CCl_4, Br and He cause a marked decrease in the K emission; N has a smaller effect; and H causes an increase in the emission. A.

COSMIC RAYS 537.591

537.591

2803. A new magnetic spectrometer. A. Alikhanyan, A. Dadayan, N. Shostakovich, G. Akopyan and M. Daïon. *Dokl. Akad. Nauk SSSR*, **80**, 37–40 (*No.* 1, 1951) *In Russian.*

Describes a 76 ton electromagnet, with poles 100×30 cm, gap 12 cm, max. field 19 000 gauss; preliminary measurements reported at up to 10 500 gauss. Trays of counters ($\sim$ 350 in all) tracked particles in and $\perp$ the median plane and through C filters of 24 cm total thickness, the presentation being hodoscopic. The Cu- and Al-walled counters had respective wall-thicknesses of 0·1 and 0·12 mm.

J. C. E. JENNINGS

537.591.1

2804. On the nucleonic component in the atmosphere. E. CLEMENTEL AND G. PUPPI. *Nuovo Cim.*, **8**, 936–51 (*Dec.*, 1951) *In Italian.*

The authors reconsider the problem of the diffusion of the low energy nucleonic component in the atmosphere, which is described by two distinct equations for protons and neutrons. The absorption mean free path in the low and middle atmosphere is consistent with experiment. The authors discuss further experimental data on vertical intensity of protons and different parameters involved in the description of the diffusion of these components. A.

537.591.1

2805. A phenomenological theory of cosmic radiation in the atmosphere. P. CALDIROLA, R. FIESCHI AND P. GULMANELLI. *Nuovo Cim.*, **9**, 5–35 (*Jan.*, 1952).

The experimental results on the composition of cosmic radiation at the top of the atmosphere are used to develop a phenomenological theory of all processes which occur in the cosmic radiation while it traverses the atmosphere. The distribution of the fast nucleonic component (protonic and neutronic), the distribution of the mesonic component and its energy spectrum and positive excess at various altitudes, and the distribution of the electronic component have been computed. The latitude effects due to the earth's magnetic field are studied accurately. The theoretical results obtained are discussed, in the light of the most recent experimental data. A.

537.591.1

2806. Cosmic rays underground. D. C. PEASLEE. *Nuovo Cim.*, **9**, 61–73 (*Jan.*, 1952).

Cosmic-rays underground are treated as entirely caused by the electromagnetic interactions of μ-mesons. Simple approximations are given for the underground spectra of μ-mesons, virtual photons, soft showers and nucleons. Comparison with experimental data is satisfactory on the absolute rate of slow neutron and nuclear star production, and on the charge ratio of star primaries, if the charged primaries are at least half protons. Disagreement is found with the observed variation of star production with depth. Comparison with observation suggests that the cross-section for nuclear excitation by γ-rays decreases on the average more slowly than $1/E$ from its large measured value $\sigma_\gamma/A \sim 1 \times 10^{-28}$ cm^2 per nucleon at $E = 200 \div 300$ MeV. This mechanism therefore predominates over meson-proton knock-on in production of the underground nucleonic component. Measurement of slow neutron or star production over large differences in depth would yield more detailed information on the behaviour of σ_γ/A at high energies. Measurement of the size-frequency distribution of soft showers at high energies would yield information about the production of neutral π-mesons. A.

537.591.1

2807. The energy spectrum of primary cosmic radiation. M. F. KAPLON, B. PETERS, H. L. REYNOLDS AND D. M. RITSON. *Phys. Rev.*, **85**, 295–309 (*Jan.* 15, 1952).

Techniques have been developed by which the energy spectrum of heavy primary nuclei can be measured in the energy range of 10^9–10^{11} eV/nucleon and of both protons and α-particles in the energy range from 10^{11} to 10^{13} eV/nucleon. It is shown that even the heaviest nuclei in the primary radiation ($Z \sim 26$) have lost their orbital electrons before entering the atmosphere, which supports the assumption that they do not proceed from the solar corona directly to the earth. It is also shown that the velocity spectrum of all primaries of charge $Z > 1$ is independent of the mass of the nuclei, and that it differs only slightly from that of the proton component in the energy interval between 3×10^8 and 10^{10} eV/nucleon. A.

537.591.1

2808. On the α-particles in primary cosmic radiation. G. SEGRÈ. *Nuovo Cim.*, **9**, 116–27 (*Feb.*, 1952) *In Italian.*

A serious disagreement exists among the published results. From an analysis of experimental data the authors think the values of the mean free path in air and in emulsion should be modified. The values suggested do not substantially differ from those assumed for protons. Corrected values for the vertical intensity of the α-particles at the top of the atmosphere, at 30° and 51° geom. lat., are also given. A.

537.591.1

2809. Soft radiation at balloon altitudes. C. L. CRITCHFIELD, E. P. NEY AND S. OLEKSA. *Phys. Rev.*, **85**, 461–7 (*Feb.* 1, 1952).

Results are given on cloud-chamber observations of electron showers and "spray" events at high altitude (18 millibars). The fluxes derived for initiating radiation are consistent with a common origin for showers and "sprays," and thus support the conclusion by Rau and Wightman that "sprays" are showers produced in a single lead plate. However, less than one-fourth as many such events occur as would be expected from observations on μ-mesons if mesons are produced with a spectrum that does not vary with altitude. If all soft radiation at 18 millibars were of primary origin, it would constitute less than 0·6% of the total cosmic-ray flux. A.

537.591.15

2810. On the mesons associated with extensive showers. S. FUBINI. *Nuovo Cim.*, **8**, 843–5) (*Nov.*, 1951) *In Italian.*

The influence of the production of π-mesons by photons on extensive air showers is considered. It is shown that an appreciable fraction of the mesons associated with showers is originated by photons. A.

537.591.15

2811. The temperature effect of extensive air showers. A. L. HODSON. *Proc. Phys. Soc. Lond.*] *A*, **64**, 1061–4 (*Dec.*, 1951).

Extensive air showers have been recorded at sea level over a period of 9 months. The data show a fairly good correlation between the shower rate and the air temperature at about one cascade unit above the apparatus, e.g. at the 950 mb level. A temperature coefficient of $-(0{\cdot}38 \pm 0{\cdot}11)\%$ per °c at this level is indicated. This may be explained by the dependence of the lateral spread of an extensive shower on the air density. A.

537.591.15

2812. The differential cross section for high energy nucleon-nucleon collisions and the mean square angle of scatter. H. S. Green and H. Messel. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1083–90 (*Dec.*, 1951).

In an attempt to account theoretically for the lateral and angular development of the penetrating particles in high-energy cosmic-ray showers, a method for deriving the differential from the total cross-section, in the laboratory frame of reference, has been developed. An integral equation is set up for the differential cross-section, and solved assuming that the differential cross-section in the centre-of-mass frame of reference is of the form $R + S' \cos^2 \bar{\theta}$, where R and S' are functions of the incident and scattered energies only. Using a form of the total cross-section derived from the analysis of high-energy cosmic-ray experiments, the mean square angle of scatter in a nucleon-nucleon collision has been calculated and found to be inversely proportional to the energy of the incident particle. The results are compared with experiments. A.

537.591.15

2813. Air-shower cores. W. E. Hazen. *Phys. Rev.*, **85**, 455–61 (*Feb.* 1, 1952).

A large cloud chamber has been used to study the density and energy distributions at the cores of air showers. The observed intensities of events with a local density $\geqslant 500$ particles/m^2 over an area less than one m^2 and of events attributed to shower axes that passed through the detector agree with ionization-chamber and G.M. counter data. The observed density and energy distributions of the shower rays in events attributed to shower cores require a multiplicity of initiators with a low average energy. On the other hand, only a minor fraction of the cores shows direct evidence for multiplicity. A consistent explanation is difficult to construct. A.

537.591.5

2814. On the positive temperature effect of the upper atmosphere and the process of meson production. A. Duperier. *J. Atmos. Terr. Phys.*, **1**, 296–310 (*No.* 5–6, 1951).

New measurements of sea-level meson intensity by means of a triple-coincidence counter arrangement with Pb absorber have confirmed the positive correlation previously found between this intensity and the temperature of the air limited by the 200 and 100 mb isobars. Also, as before, lower layers appear to have no appreciable contribution to this temperature effect. The analysis has been extended to include the temperature up to the 50 mb level. The correlation of meson intensity with the temperature of the whole region 50–200 mb is always better than that with the temperature of the 100–200 mb layer. The magnitude of the effect in the first case appears to be twice as great. Another feature is that the effect seems to decrease with increasing zenith angle of the particles traversing the recorder. All these features appear to be satisfactorily explained by assuming that μ-mesons at sea-level are the result of disintegration of π-mesons produced in the upper atmosphere and that the absorption of the π-meson-producing primaries follows an exponential law. The observed values of the effect seem, however, to be larger by a factor of 2 or 3 than can be explained by such an assumption. To account for this effect it would be necessary for the lifetime of the π-meson to be of the order of 7 or 8×10^{-8} sec. The possible contribution to the effect by heavier mesons is considered. A.

537.591.5

2815. Cosmic ray evidence on the μ-meson magnetic moment. D. C. Peaslee. *Nuovo Cim.*, **9**, 56–60 (*Jan.*, 1952).

A survey is made to determine what information is provided by the intensity/depth relation of cosmic rays underground on the possibly anomalous character of the μ-meson magnetic moment. Energy losses due to ionization, bremsstrahlung and electron pair creation by normal and anomalous Dirac particles are discussed. It is concluded that if the magnetic moment in terms of the Bohr magneton is $\mu_0(1 + \delta)$, the only limitation provided by present experience at depths of 3 000 m w.e. or less is $|\delta| \lesssim 1$. A.

537.591.5

2816. The variation of intensity of fast cosmic-ray neutrons with altitude. L. F. Curtiss and P. S. Gill. *Phys. Rev.*, **85**, 309–12 (*Jan.* 15, 1952).

Using BF_3 proportional counters, containing boron enriched in B^{10}, imbedded in a paraffin block $15 \times 15 \times 17$ in, as a moderator of fast neutrons, the intensity of such neutrons generated in the atmosphere by cosmic rays has been measured at a number of altitudes between 5 000 and 13 000 ft above sea level. These locations were all along the same geomagnetic latitude of 20° 32′ N in Kashmir. The intensity thus measured was found to increase approximately in an exponential manner with decreasing atmospheric pressure under the conditions of the experiments, in general agreement with observations made by other investigators in the free atmosphere, giving an attenuation length in the atmosphere of 128 g/cm^2. A.

537.591.5 : 523.72

2817. A solar component of the primary cosmic radiation. J. A. Simpson, W. Fonger and L. Wilcox. Letter in *Phys. Rev.*, **85**, 366–8 (*Jan.* 15, 1952).

Twelve-hourly means of the neutron intensity from evaporation stars in Pb are correlated with 2 800 Mc/s solar noise and with the 27 day recurrence of active regions on the sun. J. G. WILSON

537.591.8

2818. An intrinsic angular analysis of cosmic ray stars. M. D. Corte and M. Giovannozzi. *Nuovo Cim.*, **8**, 741–8 (*Oct.*, 1951).

An intrinsic analysis of three-pronged stars has been carried out. From the distribution of "resultants," "apertures" and "volumes," it appears reasonable to assume that a certain number of "recoils" are due to a fission-like process. For low-energy stars, there is some experimental evidence of the complete disintegration of light nuclei. A.

537.591.8

2819. High energy nuclear interactions of cosmic ray particles close to the top of the atmosphere. M. L. Vidale and M. Schein. *Nuovo Cim.*, **8**, 774–97 (*Oct.*, 1951).

Counter telescopes have been flown with plastic

balloons to a maximum altitude of 94 000 ft. Intensity *v.* pressure curves have been obtained at geomagnetic latitudes of $\lambda = 55°$, 41° and 28° for the total cosmic radiation and for the components capable of traversing 4, 7·5 and 12 cm of lead. The energy spectrum of primary cosmic-ray particles has been derived from the extrapolation of the intensity of the total radiation to the top of the atmosphere. Results indicate that the radiation originating from primaries in the energy range of 1 000–4 000 MeV (cut-off energies at $\lambda = 55°$ and 41°) is predominantly of a nucleonic nature. The absence of an electronic component can be explained by assuming that, close to the top of the atmosphere, electrons originate predominantly from the decay of neutral mesons and that in this energy range the probability of producing mesons is quite small. In sharp contrast, the soft component originating from primaries in the range of 4 000–8 000 MeV (cut-off at $\lambda = 41°$ and 28°) multiplies rapidly in the atmosphere. It is concluded that the probability of producing neutral mesons singly reaches nearly its saturation value at energies of the primary radiation in that range. At energies higher than 8 000 MeV this effect is even more pronounced due to the contribution of the plural production of mesons. To study the production of mesons in the interaction of cosmic-ray particles with a liquid H target, a counter experiment was carried out at an altitude of 90 000 ft. From the narrow angular distribution of the events originating in liquid H (total angular spread ~15°), sharply different from those originating in the walls of the Dewar container (minimum angular spread ~50°), it is concluded that they were produced by very high energy primary particles. It is estimated that the events in H resulted mostly (80%) from the interaction of primary protons of an average energy of 50 000–100 000 MeV in which a minimum of four mesons were produced. Penetrating showers in lead have been investigated at $\lambda = 55°$ and 28°. Between these two latitudes, at atm. press. 1·5 cm Hg, the ratio of the radiation producing penetrating showers amounts to 1·5, as compared to 2·9 for the hard component and 4·1 for the total radiation. A.

537.591.8

2820. Detection of nuclear interactions by means of a cloud chamber containing a crystal of sodium iodide. G. Salvini. *Nuovo Cim.*, **8**, 798–805 (*Oct.*, 1951).

A cloud chamber with a proportional crystal inside was operated to establish some properties of the cosmic-ray nuclear events, whose study is complicated or impossible in cloud chambers triggered with G.M. counters, for the selection introduced in detecting the events. The apparatus is described, and the results obtained in sixty days at sea level are given, in regard to the mean free path of the shower particles in C (108 g/cm²), and to the probability of production of the electromagnetic component in high-energy nucleon-nucleus collisions ($\sigma \sim \frac{1}{4}$ of the geometrical). A.

537.591.8

2821. On the problem of the generation of mesons and the effect of latitude. II. M. Ferretti Sforzini. *Nuovo Cim.*, **8**, 909–13 (*Dec.*, 1951) *In Italian.*

Using the results obtained in Pt I [Abstr. 7348 (1950)] for the determination of the number $\Lambda(W, E, \lambda)$ of mesons which arrive at sea level from all possible directions, and which have been generated with an energy E by a nucleon of energy W at a latitude λ, the total intensity of meson radiation at sea level has been calculated as a function of the latitude, using the Heisenberg hypothesis of production. The results of calculation are compared with the experimental data. A.

537.591.8

2822. Nuclear interactions of the decay products of a neutral *V*-particle. H. Bridge, H. Courant and B. Rossi. Letter in *Phys. Rev.*, **85**, 159 (*Jan.* 1, 1952).

A cloud chamber photograph in a multiplate chamber at 10 600 ft altitude shows the apparent nuclear interaction in Pb of both decay secondaries of a neutral *V*-particle. J. G. WILSON

537.591.8

2823. Statistical problems concerning the angular distribution of prongs in stars produced by cosmic radiation. G. Lovera. *Nuovo Cim.*, **9**, 134–40 (*Feb.*, 1952) *In Italian.*

Some deviations from isotropy in the intrinsic angular distribution of prongs, in cosmic-ray stars, which had been produced in nuclear plates, can be accounted for by means of the statistics of correlated events. A.

MAGNETISM 538

538.082.743

2824. Development and use of a probe for the measurement of magnetic fields in the investigation of ferromagnetic materials. F. Brandstaetter. *Öst. Ingen.-Arch.*, **6**, 20–30 (*No.* 1, 1951) *In German.*

The probe consists of a very small (0·1 × 2 × 40 mm) double transformer with Permalloy cores, the secondary windings of which are in exact opposition in the absence of a magnetic field but cease to be so when a low homogeneous field is applied. The aim of the probe is the measurement of low fields (~0·5 oersted) in the neighbourhood of the ferromagnetic test body and over very small parts of its surface. Details of the instrument are given, and its performance and sensitivity using a long soft iron strip, inhomogeneous along its length, are described. E. P. WOHLFARTH

538.113 : 537.122

2825. The diamagnetism of free electrons. E. H. Sondheimer and A. H. Wilson. *Proc. Roy. Soc. A*, **210**, 173–90 (*Dec.* 20, 1951).

A rigorous formulation is given of the quantum theory of the diamagnetism of free electrons. It is shown that Z, the partition function in classical statistics, may be calculated for arbitrary magnetic fields and temperatures without explicit knowledge of the energy levels, and complicated arguments involving boundary electrons are therefore unnecessary. It is further shown that the phenomena which arise in Fermi–Dirac statistics are determined by the singularities of Z regarded as a function of a complex variable, and, in particular, that the poles of Z give rise to the de Haas–van Alphen effect (the periodic field dependence of the susceptibility at low tempera-

tures). The theory confirms the results obtained in earlier treatments. A.

538.114

2826. Antiferromagnetism by the Bethe method. J. M. ZIMAN. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1108–12 (*Dec.*, 1951).

The Bethe method for order-disorder is applied to a lattice of magnetic dipoles with antiferromagnetic nearest-neighbour interactions. Magnetization and entropy are calculated for all values of temperature and magnetic field, and an anti-parallel ordered phase is found below a definite transition curve. The computed curves agree qualitatively with those observed experimentally with certain paramagnetic salts at low temperatures. A.

538.114

2827. Theory of antiferromagnetic resonance. F. KEFFER AND C. KITTEL. *Phys. Rev.*, **85**, 329–37 (*Jan.* 15, 1952).

The spin resonance condition $\omega/\gamma = H_0 \pm [H_A(2H_E + H_A)]^{\frac{1}{2}}$ previously given by Kittel for a disk-shaped single-domain uniaxial or cubic antiferromagnetic crystal at 0°K with H_0 parallel to the domain axis is extended by classical calculations to cover finite temperature, ellipsoidal shape, orthorhombic symmetry, generalized two-lattice anisotropy and arbitrary static field direction. The normal precessional modes are discussed. A quantum-mechanical derivation of the resonance equations is carried out by the method developed by Van Vleck for ferromagnetic resonance; no new features are introduced by the quantum-mechanical calculation. Several factors contributing to the line width are considered. Existing experimental data on antiferromagnetic resonance are reviewed; the data are scanty and taken in circumstances not closely related to the situation envisaged by the theory. A.

538.114 : 539.11

2828. The saturation magnetic moment of alloys on the collective electron theory. J. E. GOLDMAN. Letter in *Phys. Rev.*, **85**, 375 (*Jan.* 15, 1952).

Gives a speculative interpretation of the deviations from the so-called Pauling curve of the variation with composition of the saturation moment of certain Ni and Co alloys. The interpretation is based on the band picture, invoking the presence of localized energy levels near the solute atoms. E. P. WOHLFARTH

538.122

2829. The use of current sheets in the design of magnets to give bounded fields of required form, free from edge distortion. H. O. W. RICHARDSON. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 5–14 (*Jan.*, 1952).

Two types of magnet winding are considered. The first, or field-terminating type, encloses a tube of force and serves as a sharp boundary to the field. The second, or iron-shrouded type, is wound against the inner surface of an iron shroud and, with a suitable distribution of turns, can generate any required shape of field in the iron enclosure. In both types stray field can be avoided if the iron return-path is infinitely permeable, or if it is covered with an "anti-reluctance" winding. A discussion is given of (*a*) the uniform field, (*b*) the field whose lines of force are coaxial circles, (*c*) the synchrotron field, and (*d*) the prolate spheroidal field, whose lines are confocal ellipses. A.

538.122

2830. The extension of the electrolytic tank method to the study of magnetic fields due to iron-clad current sheets in three dimensions. H. O. W. RICHARDSON. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 15–18 (*Jan.*, 1952).

An application of the electrolytic tank method to plot the magnetic fields of a current sheet is described. In general, three-dimensional fields due to currents can be plotted, provided that the current is close to the surface of a piece of permeable iron. A.

538.22

2831. The magnetic susceptibility of chromium. T. R. MCGUIRE AND C. J. KRIESSMAN. *Phys. Rev.*, **85**, 452–4 (*Feb.* 1, 1952).

The susceptibility has been measured from −195°C to 1 440°C and is found to increase from $3{\cdot}42\times10^{-6}$ to approximately $4{\cdot}30\times10^{-6}$ e.m.u./g at the highest temperature. A transition is recorded in the region of 1 400°C marked by a sharp increase in susceptibility and a temperature hysteresis. A.

538.221

2832. Interaction between the *d*-shells in the transition metals. IV. The intrinsic antiferromagnetic character of iron. C. ZENER. *Phys. Rev.*, **85**, 324–8 (*Jan.* 15, 1952).

For Pt III, see Abstr. 7195 (1951). The principles developed in the previous papers of this series are applied to interpret the presence of ferromagnetism in b.c.c. iron, its absence in f.c.c. iron. It is found necessary to introduce a new principle, namely that for minimum energy the *d*-shell electrons are distributed among the atoms so as to maximize the total number of pairs of electrons having like spin within the indivdiual atoms. This principle leads to the viewpoint that, at least on a local scale, the b.c.c. iron lattice consists of the superposition of two interpenetrating simple cubic lattices of atoms having *d*-shell spins of different magnitudes and of opposite direction. The same principles lead directly to the observed saturation magnetizations of all iron base alloys. A.

538.221

2833. An interpretation of the magnetic properties of some iron-oxide powders. W. P. OSMOND. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 121–34 (*Feb.*, 1952).

The observed magnetic properties of fine dispersed powders of the ferromagnetic iron oxides are discussed in the light of modern theories of the magnetization of ferrites and of ferromagnetics containing non-magnetic inclusions. The individual powder particles are shown to be probably of single-domain size, and the relative coercivities of γ-ferric oxide powders of nearly spherical and markedly acicular grains are qualitatively in agreement with theory, on the grounds of shape anisotropy. After allowance is made for volume concentration and small departures from stoichiometric composition, the ratio of the coercivities of apparently identical acicular powders of γ-ferric oxide and of magnetite is found to be approximately that of the saturation magnetization per ferric ion rather than that of the value per unit volume, and both coercivities are lower than theory would predict. It is concluded that magneto-crystalline anisotropy is also involved. In contrast, relative and actual

values of intrinsic induction at the beginning of the approach to saturation are in satisfactory agreement with theory, as are the relative values at remanence although the actual values here are rather low. It is hoped to extend the study to larger departures from stoichiometric composition involving partial transformation to the antiferromagnetic iron oxides α–Fe_2O_3 and FeO. A.

538.221

2834. The domain structure of a silicon-iron crystal. L. F. Bates and C. D. Mee. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 129–40 (*Feb.*, 1952).

Powder patterns have been obtained on the (100) and (011) surfaces of a carefully shaped single crystal of 3% silicon-iron, of dimensions 13 mm × 6 mm × 6 mm, and these have permitted a more thorough quantitative test of proposed ferromagnetic domain structures than has been made hitherto. The patterns on the (011) surface are very beautiful and complicated. Although the measurements of domain spacings on both planes under Mode III magnetization conditions, as well as measurements of the angles between the domain vectors and main domain boundaries, confirm the essential features of the main structure proposed by Néel, there are found considerable numerical discrepancies which are attributed to the complicated nature of the closure domains on the (011) surface.

A.

538.221

2835. A study of surface closure domains by the powder pattern technique. L. F. Bates and C. D. Mee. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 140–4 (*Feb.*, 1952).

The powder patterns in the neighbourhood of cavities and inclusions on the surfaces of single crystals of silicon-iron have been studied, and the photographs obtained are evidence for the essential correctness of current views on closure domain structures. A.

538.222

2836. Coupling between magnetic moments in molecules containing three iron atoms. G. Foëx, B. Tsaï and J. Wucher. *C.R. Acad. Sci.* [*Paris*] **233**, 1432–3 (*Dec.* 3, 1951) *In French.*

Measurements were carried out of the susceptibility of a ferric acetate and a ferric benzoate between 14°K and room temperature. In the higher temperature range the Curie–Weiss law is obeyed, but below 20°K $1/\chi$ decreases more rapidly with decreasing temperature and extrapolates to zero near 0°K. It is suggested that the iron atoms in each molecule are rigidly coupled at the lower temperatures.

E. P. WOHLFARTH

538.222

2837. A tentative interpretation of the magnetic behaviour of Pr_6O_{11}. K. Yosida. Letter in *J. Chem. Phys.*, **20**, 202 (*Jan.*, 1952).

The deviations of the susceptibility/temperature curve from the Curie–Weiss law [Abstr. 7099 (1951)] are interpreted by ascribing to the oxide defect antiferromagnetic, or ferrimagnetic, behaviour. X-ray data are invoked in support of this view [Abstr. 6832 (1950)]. E. P. WOHLFARTH

538.222

2838. Spin paramagnetism of Cr^{+++} at liquid helium temperatures and high magnetic fields. W. E. Henry. Letter in *Phys. Rev.*, **85**, 487 (*Feb.* 1, 1952).

Low-temperature, high-field magnetic measurements on potassium chromium alum are described. A plot of the relative magnetization against H/T is in good agreement with the Brillouin function, with $S = \frac{3}{2}$, $g = 2$ (spin only due to quenching of orbital moment). For the largest value of H/T ($\sim 3 \cdot 9 \times 10^3$) saturation is 99·5% complete. E. P. WOHLFARTH

538.224

2839. The diamagnetism of ammonium ion. M. Prasad, C. R. Kanekar, D. D. Khanolkar and M. G. Datar. *J. Chem. Phys.*, **20**, 129–31 (*Jan.*, 1952).

A linear relation between the molar susceptibilities of inorganic and organic salts of Li, NH_4 and K containing a common anion and the number of electrons in the cations has been established. This relation has been used to deduce susceptibilities of ammonium ion and inorganic and organic anions in combination with it. A.

538.224 : 537.311.33

2840. Magnetism of free electrons and holes in semiconductors. G. Busch and E. Moser. *Helv. Phys. Acta*, **24**, 329–31 (*No.* 4, 1951) *In German.*

Résumé of a paper on the magnetic susceptibility of grey tin previously abstracted [Abstr. 1958 (1952)]. [The present paper contains an error in the main equation, where the exponent of kT should be $\frac{1}{2}$ instead of $\frac{3}{2}$.] E. P. WOHLFARTH

538.23 : 621.317.431

2841. A two fluxmeter method of measuring ferromagnetic hysteresis loss. H. Aspden. *J. Sci. Instrum.*, **29**, 5–7 (*Jan.*, 1952).

Ferromagnetic hysteresis loss is usually measured by the method of reversals or the step-by-step method, both of which involve the use of a ballistic galvanometer or a fluxmeter. The necessity for recording observations and measuring the area of the hysteresis loop can be eliminated by using a second fluxmeter to integrate successive electrical discharges, which are initiated by a chosen change in flux density and are proportional to the magnetizing field. The total deflection of this second fluxmeter over one complete cycle of magnetization is a direct measure of the hysteresis loss. It is possible, without sacrificing accuracy, to reduce the time of measurement to a small fraction of that usually required. A.

538.24

2842. The magnetization of steels in weak magnetic fields: the effects of time, stresses, shocks and transverse magnetic fields. L. Lliboutry. *Ann. Phys.* [*Paris*] **6**, 731–829 (*Sept.–Oct.*, 1951) *In French.*

Experimental and theoretical results on the effects of factors which are usually deliberately eliminated from magnetic measurements. Consideration is confined to the region of validity of the Rayleigh law and it is shown that, with a small change of constant, the law remains valid up to fields of about one-half the coercive force. In these larger fields, however, the magnetization is also a function of the number of cycles of magnetization through which the material is taken, increasing as the number of cycles increases.

The effects of tension and compression, of shocks and of transverse magnetic fields on magnetization in the Rayleigh region are also considered and their relations to magnetic viscosity discussed. The relation between magnetic viscosity and the mean volume of Barkhausen discontinuities is examined in terms of Néel's theory. A. E. DE BARR

538.24 : 539.152.2

Aligning atomic nuclei by double radioelectric resonance. *See Abstr.* 2907

538.244

2843. Surface currents and magnetization. P. BAUDOUX. *Bull. Acad. Roy. Belge Cl. Sci.*, **37**, 753–61 (*No.* 8–9, 1951) *In French.*

A volume distribution of current may be ideally divided into two separate parts by a surface on which suitable surface currents of density M are assumed, without altering the current distribution. It is proved that, in a magnetic medium, M coincides with the magnetization. L. PINCHERLE

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.3

2844. An asymptotic solution of Maxwell's equations. M. KLINE. *New York University, Washington Square College, Mathematics Research Group, Research Rep. No. EM–24*, ii + 43 *pp.* (1950).

In the field created by an electric charge suddenly placed in space at zero time, any component of the field vectors approaches $u \exp(-i\omega t)$ when transient phenomena have died away. An asymptotic expansion of u can be given in powers of the wavelength. The coefficients are simply related to the discontinuities in the time derivatives of the pulse solution. A possible method for deriving these discontinuities without a full knowledge of the pulse solution is indicated. MATHEMATICAL REVIEWS

538.3

2845. On the solution of non-stationary boundary problems in electrodynamics. N. V. ZERNOV. *Dokl. Akad. Nauk SSSR*, **80**, 33–5 (*No.* 1, 1951) *In Russian.*

Mathematical. A solution is sought of $\Delta E = 1/v^2 \partial^2 E/\partial E$ under initial and boundary conditions together with $\operatorname{div} E = 0$ in the form of the vector analogue of the generalized Fourier integral. The problem is reduced to a similar electrodynamic problem in a system at rest. J. JACOBS

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.56

2846. On the analytical expression of Huygens' principle for e.m. waves. A. DA SILVEIRA. *C.R. Acad. Sci.* [*Paris*] **233**, 1269–72 (*Nov.* 19, 1951) *In French.*

538.56 : 621.3.016.2

2847. Instantaneous power spectra. C. H. PAGE. *J. Appl. Phys.*, **23**, 103–6 (*Jan.*, 1952).

The intuitive concept of a changing spectrum is discussed. The instantaneous power spectrum is defined mathematically and used to make the intuitive concepts more precise. It depends upon the past history of a signal, but not upon the future. Integration of the instantaneous power spectrum over time yields the conventional energy spectrum. The instantaneous power spectrum of a random function may be averaged over the ensemble of functions, with a resulting stochastic average instantaneous power spectrum that is equal to the conventional time average power spectrum of a stochastic process. A.

538.561

2848. On the non-linear theory of electron plasma oscillations. A. I. AKHIEZER AND G. YA. LYUBARSKIĬ. *Dokl. Akad. Nauk SSSR*, 193–5 (*No.* 2, 1951) *In Russian.*

The usual linear approximation is untenable in a number of applications. A solution of the simplest unidimensional non-linear case, of sustained oscillation in an infinite plasma at absolute zero, is derived. F. QUELON

538.561 : 551.594.9

2849. Ionospheric thermal radiation at radio frequencies. J. L. PAWSEY, L. L. MCCREADY AND F. F. GARDNER. *J. Atmos. Terr. Phys.*, **1**, 261–77 (*No.* 5–6, 1951).

Radio noise on medium frequencies consists largely of man-made noise and atmospherics, but it should also contain a component due to thermal radiation from the ionosphere. This thermal radiation from the ionosphere has been identified and measured. It is very weak, corresponding to an effective temperature of about 300°K, or a field strength of about 10^{-9} V/m in a frequency band of 1 kc/s, under the conditions of observation. It is necessary to minimize man-made noise and atmospherics by observing during the midday hours at places remote from electrical machinery. These observations introduce a new method for studying the electron temperature in the absorbing (and emitting) part of the ionosphere, which, for the frequencies used, is at a height of about 70 or 80 km. The measured temperatures, 240 to 290°K, agree with other observations of temperatures at these heights. A.

538.565 : 621.396.671 : 621.396.611.4

2850. Electromagnetic resonant behavior of a confocal spheroidal cavity system in the microwave region. J. C. SIMONS AND J. C. SLATER. *J. Appl. Phys.*, **22**, 29–30 (*Jan.*, 1952).

The resonance of a small spheroidal object in a large spheroidal cavity is investigated. This approximates the case of a thin needle-like aerial in a large cavity. It is shown that this needle, if thin enough, shows marked resonant properties, in that when the cavity is tuned to a resonant frequency defined by the needle, the magnetic field on the surface of the needle is greatly enhanced. This property can be used in a practical way, in measuring surface impedance of the material of which the needle is composed: at resonance most of the loss in the cavity is located at the surface of the needle and depends on the material of which it is composed. A.

538.566

2851. Reflection of electromagnetic waves from slightly rough surfaces. S. O. RICE. *Commun. Pure Appl. Math.*, **4**, 351–78 (*Aug.*, 1951).

Approximate analysis of the reflection of plane e.m. waves from a surface which is almost flat. Horizontally and vertically polarized waves are considered. Expressions for the components of the reflected field and for the reflection coefficient are obtained. The problem of surface wave propagation corresponding roughly to the case of grazing incidence and vertical polarization is analysed. It is found that the guiding action of the surface is produced when the Fourier components of the surface have wavelengths shorter than those of the e.m. wave whereas attenuation through scattering is due to the components of longer wavelengths. Z. F. WOJNAR

538.566

2852. On the scattered reflection of electromagnetic waves. V. TWERSKY. *New York University, Washington Square College, Mathematics Research Group, Research Rep. No. EM–26*, ii + 82 *pp.* (1951).

The non-specular reflection of plane waves of arbitrary polarization by certain perfectly conducting surfaces composed of semi-cylindrical or hemispherical bosses on an infinite plane is analysed. Expressions are obtained for the ratios of the reflected intensities and radial energy flux polarized parallel and perpendicular to the plane of incidence, and the case of an unpolarized incident wave is also studied.

MATHEMATICAL REVIEWS

538.566

2853. An experiment using plane gratings with microwaves. L. GRILLINI. *Nuovo Cim.*, **8**, 952–9 (*Dec.*, 1951) *In Italian.*

A direct experimental proof has been given of the Fraunhofer pattern of a diffraction grating. Microwaves of 32 mm were used. The diffraction screen was a grating made of metal strips. The intensity distribution is related to the angle of incidence. The period of the grating was so chosen that only the central and the first-order waves were possible. A notable difference was observed if the electric vector E was parallel or normal to the grating strips. A.

538.566 : 534.26

Multiple scattering of radiation by an arbitrary configuration of parallel cylinders. *See Abstr.* 2544

538.566 : 538.614 : 621.318.1 : 621.3.011

2854. The ferromagnetic Faraday effect at microwave frequencies and its applications. The microwave gyrator. C. L. HOGAN. *Bell Syst. Tech. J.*, **31**, 1–31 (*Jan.*, 1952).

A new microwave circuit element dependent on the Faraday rotation of a polarized wave has been developed. The element violates the reciprocity theorem and, because it shares this property with a gyroscope and because it is dependent on gyromagnetic resonance absorption, it has been termed a microwave gyrator. It is a low-loss broadband device with many applications. Among these are one-way transmission systems, microwave circulators, microwave switches, electrically controlled variable attenuators and modulators. The microwave gyrator has been realized by making use of the Faraday rotation in pieces of ferrite placed in the waveguide. Polder has previously shown, in his analysis of the gyromagnetic resonance phenomenon, that ferromagnetic substances should show appreciable Faraday rotations at microwave frequencies. In the present study, Polder's analysis has been extended to include a wave being propagated through a ferromagnetic substance with dielectric and magnetic loss, and data are presented which give experimental verification of the theory. In addition an experimental technique is described which may be of some interest in studying the properties of ferrites at microwave frequencies. A.

538.566 : 621.392.26

2855. Compilation of the propagation constants of an inhomogeneously-filled waveguide. L. G. CHAMBERS. *Brit. J. Appl. Phys.*, **3**, 19–21 (*Jan.*, 1952).

Use is made of the Rayleigh–Ritz method of finding frequencies of vibration of a mechanical system, for finding the propagation constants of an inhomogeneously-filled waveguide. A.

538.566 : 621.396.671

2856. An experimental investigation of the dielectric rod antenna of circular cross section excited in rotationally symmetrical modes. C. M. MCKINNEY. *J. Appl. Phys.*, **23**, 11–13 (*Jan.*, 1952).

The radiation patterns were measured for three series of dielectric rod aerials of circular cross-section excited in the TM_{01} mode at a frequency of 9 275 Mc/s. Only one parameter was changed in each series of rods so that the effect of this parameter on the pattern could be studied. Dielectric aerials excited in the TM_{01} mode have a null in the radiation pattern in the forward direction. It was found that maximum attenuation of secondary lobes was obtained using large diameter rods but sharper and deeper central nulls were obtained with small diameter rods. It was also noted that the deepest central null was obtained using a rod of uniform cross-section. For uniformly tapered rods of various lengths, the maximum secondary lobe attenuation as well as the sharpest and deepest central null was obtained using the longest rod. The radiation patterns of the aerials excited in the TE_{01} mode were of the same nature as those obtained using the TM_{01} mode. Measurements were made also of the electric field strength on the surfaces of the radiating rods and these measurements were correlated with the radiation patterns. A.

538.566.2/.3 : 621.396.11

2857. Propagation in a non-homogeneous atmosphere. B. FRIEDMAN. *Commun. Pure Appl. Math.*, **4**, 317–50 (*Aug.*, 1951).

A full exposition is given of the theory of propagation in a spherically stratified nn-homogeneous atmosphere. The analysis and results, applicable to both ionospheric and tropospheric problems, are discussed in relation to those of other workers.

W. J. G. BEYNON

538.566.2

2858. Diffraction by a dielectric wedge with application to propagation through a cold front. S. KARP AND W. SOLLFREY. *New York University, Washington Square College, Mathematics Research Group, Research Rep. No. EM–23*, ii + 45 (1950).

Diffraction of plane polarized electromagnetic

waves is studied. The dielectric constant of the wedge differs only slightly from that of free space. The reflected and refracted waves are derived by geometrical optics, and the angular pattern of the diffracted cylindrical waves is found by stationary-phase methods. The results are applied to aeroplane reception of electromagnetic signals when the aeroplane crosses the cold front. MATHEMATICAL REVIEWS

538.566.2 : 621.396.11

2859. Measurements of the parameters involved in the theory of radio scattering in the troposphere. C. M. CRAIN AND J. R. GERHARDT. *Proc. Inst. Radio Engrs*, **40**, 50–4 (*Jan.*, 1952).

Measurements have been made of refractive index and associated temperature fluctuations since 1948, with a more detailed study from 10 in to 50 ft above the ground since December 1949. The paper includes a brief discussion of the recording refractometer and recording thermometer used for these studies, a meteorological analysis of the problem, and tracings of the refractive index and temperature fluctuations for several various conditions of the lower atmosphere. A.

538.566.3

2860. On the definition of virtual height. J. SHMOYS. *New York University, Washington Square College, Mathematics Research Group, Research Rep. No. EM–27*, ii + 43 *pp.* (1951).

The geometrical-optics and wave theoretic definitions for various simple types of charge distribution in the ionosphere, including the Epstein and parabolic layers, are compared. Examples indicate that the relation between virtual height and frequency derivative of phase is not valid when the reflected wave contains more than one pulse, and that this derivative cannot then be interpreted as the time delay of any one of the pulses. The problem of evaluating the time delay of each reflected pulse in the latter case remains open. MATHEMATICAL REVIEWS

538.566.3

2861. Field representations in spherically stratified regions. N. MARCUVITZ. *Commun. Pure Appl. Math.*, **4**, 263–316 (*Aug.*, 1951).

A study is made of the use of the method of guided waves in obtaining the general representation theory required for the solution of diffraction problems involving discontinuities in spherical regions. W. J. G. BEYNON

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11 : 535.343.2

The structure of the long wave absorption edge of insulating crystals. *See Abstr.* 2610

539.11 : 535.343.2–15

Infra-red spectra and the solid state. *See Abstr.* 2613–14

MOLECULAR STRUCTURE 539.13

539.13

2862. Remarks on the calculation of relaxation times of molecules. Z. I. SLAWSKY, F. W. DE WETTE AND S. R. DE GROOT. *Nuovo Cim.*, **7**, 328–31 (*Suppl. No.* 2, 1950) *In French.*

The problem of calculating molecular relaxation times is essentially that of molecular collisions. Experiments show that the relaxation times for the degrees of freedom associated with vibration are very different for the different molecules and depend on the intermolecular forces. A theory has been developed using Mott and Massey's "distorted" waves in combination with states of stationary perturbation. Schrödinger's equation is used for diatomic molecules, and an equation is deduced to describe the molecular collision. A. C. WHIFFIN

539.13 : 535.343 : 537.226.2

2863. On the torsional vibrations of long chain molecules. B. SZIGETI. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 19–32 (*Jan.*, 1952).

Simplified models are discussed for long chain molecules in which all units are equal except for one which is heavier than the others. Certain general conclusions are reached for the vibrations of such molecules. The results will be applied to the out-of-plane or torsional vibrations of long chain ketones in a following paper. A.

539.13 : 541.57

An interpretation of bond lengths and a classification of bonds. *See Abstr.* 3088

539.13 : 541.64 : 530.162

2864. Random flight with multiple partial correlations. C. M. TCHEN. *J. Chem. Phys.*, **20**, 214–17 (*Feb.*, 1952).

The fundamental statistical properties of a linear polymer can be best studied by a more general model of random flight with multiple partial correlations. Results show that the problems of free rotation and symmetrically restricted rotation in polymers correspond to one and two partial correlations, respectively. The present study of the correlation function by means of difference equations enables one to carry out the generalization to higher orders of partial correlations. The mean square value of the distance r between the ends of the chain is studied for both finite and infinite number of links, and for multiple partial correlations. It is shown that the case of one partial correlation corresponds to a Markoff chain, and the distribution of r is found to be normal. A.

539.132

2865. Rate of formation of molecules by radiative association. D. R. BATES. *Mon. Not. Roy. Astron. Soc.*, **111**, 303–14 (*No.* 3, 1951).

A theoretical study is made of the rate at which free atoms form molecules by radiative association. Previous treatments of this problem are shown to be in error. A revised formula for the coefficient expressing the rate is derived. Approximate methods of evaluating this formula are discussed; and tables, designed to ease the computational labour, are presented. The methods developed are used to obtain the rate coefficients for CH, CH^+, N_2^+ and

H_2^+ formation as these are of astrophysical or geophysical importance. In the case of H_2^+ the calculations can be performed with some precision. Free-free radiative collisions between H atoms and H^+ ions are also investigated. A.

539.132

2866. Atoms in molecules and crystals. W. MOFFITT. *Proc. Roy. Soc. A*, **210**, 245–68 (*Dec.* 20, 1951).

A new approach to the problems of the electronic structure of molecules is proposed. The basis for this treatment is the observation that the energies of atomization of molecules are small relative to their total energies. Accordingly, a perturbation theory is developed in which the unperturbed states consist of isolated atoms and ions, and the mutual approach of these atomic species is treated as the result of a perturbation. In common with other theories, the total molecular eigenfunction is expressed linearly in terms of more simple functions. It is argued that when these more simple functions are of the orbital type, this expansion converges only slowly. On the other hand, if the orbital approach is abandoned, an expansion in terms of so-called composite functions will converge much more rapidly. This representation has the advantage that, at infinite internuclear separations, the composite functions are eigenfunctions. A new use is found for atomic orbitals. They are used in order to construct approximate atomic functions, for which purpose they were originally intended. These approximate atomic functions are then employed to estimate only the perturbation or interaction terms. The energies of the unperturbed states (isolated atoms and ions) must either be determined by the use of more complex atomic functions, or by an appeal to experimentally determined atomic term values. A.

539.132

2867. Extension of the idea of charge. R. DAUDEL AND A. LAFORGUE. *C.R. Acad. Sci.* [*Paris*] **233**, 1608–10 (*Dec.* 19, 1951) *In French.*

See also Abstr. 443 (1952). Configuration interaction is taken into account in the definition of charge now extended to cover the case where atomic orbitals differ, as in heteroatomic conjugated molecules.

J. JACOBS

539.132 : 541.57

2868. The hydrogen bond. L. KELLNER. *Rep. Phys. Soc. Progr. Phys.*, **15**, 1–23 (1952).

A survey is given of the infrared spectra of substances possessing hydroxyl groups and of the position of the O–H valence vibration in the solid, liquid and gaseous state and in dilute solutions. The spectra of water, alcohols and carboxylic acids are discussed separately; and evidence for molecular association is adduced from the experiments on dilute solutions and liquids. The degree of polymerization of various alcohols as a function of the concentration has been obtained from quantitative absorption measurements under the assumption that the mass action law holds. The investigation of the temperature effect of the O–H valence vibration has led to an evaluation of the heat of association between a hydroxyl group and the oxygen of an adjacent group or molecule which is of the order of the values obtained from vapour pressure and cryoscopic measurements. Finally, the nature of the forces producing this association is discussed. It is shown that the van der Waals' forces are too small to be solely responsible for this special bond, the so-called hydrogen bond, and that the hydrogen bond must be attributed to a quantum-mechanical effect. An account is given of the possible origins of such a quantum-mechanical binding force. (Bibl. 59 items.) A.

539.132 : 537.534.74

2869. The scattering of atoms from diatomic molecules. C. F. CURTISS AND F. T. ADLER. *J. Chem. Phys.*, **20**, 249–56 (*Feb.*, 1952).

The quantum mechanics of the collision of an atom with a diatomic molecule is discussed. This is an example of the scattering of particles by a non-spherical potential field. In the region in which the atom and molecule are not interacting, the wave function for the system can be written as the product of a wave function for the free atom and that of the free molecule. By an analysis of this function one can write the asymptotic form of the true wave function in the terms of the scattering coefficients, representing the angular dependence of the transition probabilities. In a previous paper [Abstr. 2891 (1951)] group theoretical arguments were used to separate the rotational co-ordinates from the *n*-particle Schroedinger equation. A set of coupled differential equations for the internal wave functions was derived. In the present paper, the scattering coefficients are obtained by an analysis of the solutions of the internal wave equations involving the three co-ordinates specifying the internal configuration. This set of equations is transformed into a set of coupled ordinary differential equations in which the coupling is the result of the transitions in the state of the molecule. The equations are solved by a perturbation method which is valid in the case of low energy collisions in which transitions occur relatively seldom. The angular transition probabilities are obtained explicitly in terms of integrals of the interaction potential and a set of phase shifts. A.

539.132 : 537.534.74

2870. On the scattering of H_2^+ by H_2. V. MYERS. Letter in *J. Chem. Phys.*, **20**, 195 (*Jan.*, 1952).

Comparison with the H_e–H_e^+ system suggests that an attractive potential in one orbital may cause a large scattering cross-section. J. JACOBS

539.132

2871. The coupling of angular momentum vectors in molecules. J. H. VAN VLECK. *Rev. Mod. Phys.*, **23**, 213–27 (*July*, 1951).

The problem is framed so that molecular angular momentum vectors obey commutation relationships analogous to those satisfied by atomic angular momentum vectors. This involves firstly reference to axes fixed in the molecule, and secondly the introduction of a "reversed" internal angular momentum $\tilde{P} = -P$, where P is the angular momentum exclusive of that of rigid rotation. In this system of reference $\tilde{P}$ and J, the total molecular angular momentum, commute, and can be used for compounding purposes like spin and orbital angular momentum vectors in atomic spectra. Transformation methods used in

atomic quantum theory are then applicable to the compounding of $\tilde{P}$ and J. To every coupling problem in molecular spectra there then corresponds a mathematically equivalent one for atoms. By applying the appropriate correlations between the molecular and atomic angular momentum vectors, the matrix elements for a particular molecular problem may be obtained from the literature (e.g. Condon and Shortley, *The Theory of Atomic Spectra*) of the mathematically equivalent atomic problem. The method is illustrated by applications under the following headings: (*a*) Polyatomic molecules devoid of internal angular momentum; (*b*) Coupling of electron spin in diatomic molecules not in Σ-states; (*c*) Λ- and ρ-type doubling; (*d*) Coupling of electron spin in polyatomic molecules; (*e*) Coupling of nuclear spin in molecules devoid of electronic spin; (*f*) Intensities and behaviour in external fields.

H. H. GREENWOOD

539.132

2872. *l*-Type doubling in energy levels of carbon dioxide coupled by Fermi resonance. J. DE HEER AND H. H. NIELSEN. *J. Chem. Phys.*, **20**, 101–4 (*Jan.*, 1952).

The *l*-type doubling in levels of linear molecules which are coupled by Fermi resonance is discussed; in particular a triad of such levels in CO_2 is considered. In principle, it becomes necessary to consider simultaneously the perturbations related to both anharmonic resonance interaction and *l*-type doubling. A further analysis reveals, however, that an approximate solution is justified, in which the resonance interaction is first considered as if *l*-type doubling did not occur and then the energy levels are found associated with $+l$ and $-l$ as a result of small perturbations on the twofold degenerate levels involved. It appears that the applicability of the well-known formula $\Delta\nu = qJ(J+1)$, in which q is the *l*-type doubling constant, is inherent to this approximation. The agreement between q values computed by this method and those obtained experimentally is very satisfactory indeed. A.

539.132

2873. The electronic structure of the oxygen molecule. W. MOFFITT. *Proc. Roy. Soc. A*, **210**, 224–45 (*Dec.* 20, 1951).

Energies of excitation of different electronic states of the oxygen molecule are calculated by the method of antisymmetrized molecular orbitals (ASMO). These are compared with the observed spectrum. It is found that the ASMO theory is most disappointing. The reasons for the failure of the method are analysed. As a result of this critical analysis, a modified method is proposed which is found to be very successful. The basis of this modification is that the approximation of using atomic orbitals should be made only in evaluating the interaction energy of the constituent atoms of a molecule, and not to assess their isolated term values. As a corollary, the location of two new states of the oxygen molecule is predicted. A.

539.132

2874. π–σ electronic states in molecules. I. The Hückel approximation. S. L. ALTMANN. *Proc. Roy. Soc. A*, **210**, 327–43 (*Jan.* 7, 1952).

A critical study is made of the usual approximation of separating the system of π-electrons from that of the σ-electrons, when studying the energy levels of conjugated systems. The usual treatment is reformulated using the valence-bond method. The only necessary assumption, here called the Hückel approximation, is that canonical structures involving π–σ or σ–σ resonance are negligible. It is then shown that π–σ and σ–σ exchange terms do not need to be taken into account explicitly because they enter as an additive constant in all the states. This cancels out by subtraction, and is therefore irrelevant when computing resonance energies. The above reformulation is important, as it shows that a complete Hamiltonian and wave function (including π, σ and hydrogen electrons) must be taken for the molecule, whereas previous *ab initio* computations of exchange integrals have been conducted with purely π-wave functions. Otherwise the results coincide with those given by empirical treatments, but the usual name of *n*-electron approximation for these, π being the number of π-electrons in the molecule, is an inappropriate one. Exchange integrals for ethylene are computed along these lines. The results provide an explanation for the hitherto empirical fact that exchange integrals in different unsaturated hydrocarbons are of the same order. The errors due to the Hückel approximation when computing resonance energies are considered. If the neglected canonical structures are now introduced, an additional stability appears due to π–σ resonance, an abbreviation which is used to denote the resonance between π and in-plane electrons. This new effect is of great importance in computing excited states, as shown in Pt II. A.

539.132

2875. π–σ electronic states in molecules. II. The singlet spectrum of ethylene and derivatives. S. L. ALTMANN. *Proc. Roy. Soc. A*, **210**, 343–54 (*Jan.* 7, 1952).

It is suggested that the failure of the Heitler–London–Slater–Pauling method to give the right transition rules for the excited levels in conjugated systems is not due chiefly to shortcomings in the valence bond method (like neglect of ionic structures) but rather to the use of the Hückel approximation (see Pt I). This is confirmed by a detailed treatment of ethylene as a twelve-electron problem by the valence-bond method. The Hückel approximation is dispensed with, so that 6 canonical structures are considered. Of these, one corresponds to the perfect pairing scheme, one to π–σ resonance in the double bond and 4 to π–*h* resonance (*h* being the hydrogen 1*s* electron) in the C–H bonds. No purely σ–σ resonance is considered. Most of the necessary exchange integrals are computed. Two of them, however, are estimated. The treatment can be extended to substituted ethylenes by changing a few exchange integrals. It is necessary here to estimate another integral. A π–σ resonance energy of 0·47 eV is obtained for the ground state of ethylene. The actual positions of the peaks of absorption obtained are not very accurate, as could be expected. They are, however, of the same order as those given by the method of the antisymmetrized molecular orbitals. A first band $^1A_{1g}$–$^1A_{2g}$, forbidden, is obtained. This is identified with the observed faint absorption starting

at 2 000 Å. The second band, allowed, is double, given by the transitions $^1A_{1g}$–$^1B_{1u}$ and $^1A_{1g}$–$^1B_{2u}$ separated by *c.* 0·2 eV (experimental 0·06 eV). These bands are identified with the strong absorption at 1 600 Å. The double nature of this band was hitherto without theoretical explanation. The distance between the first forbidden band and the centre of the second is 1·4 eV (experimental *c.* 1·1 eV). The second band is shifted towards the red by tetra-alkyl substitution by 0·9 eV (experimental 1 eV). There is no need to have recourse to hyperconjugation to explain this last fact. A.

539.132

2876. Transition probabilities. II. Calculation of semi-theoretical *f*-numbers for hydrogen using the dipole velocity operator. H. SHULL. *J. Chem. Phys.*, **20**, 18–21 (*Jan.*, 1952).

The computations of Mulliken and Rieke using the LCAO MO and the AO methods for transition probabilities of the Lyman ($^1\Sigma_g^+$–$^1\Sigma_u^+$) and Werner ($^1\Sigma_g^+$–$^1\Pi_u$) transitions in H have been repeated using the alternative velocity form of the transition moment operator. It is found that, for an effective ζ value of 1·2 for the 1*s* AO (the variation value) and a suitable Rydberg form for the excited state, the transition probabilities calculated from these two operators agree well. In addition there is quite good agreement between the AO and MO methods in each instance and between the calculated and experimental value for the sum of the strengths of the Lyman and Werner transitions. [For Pt I, see Abstr. 185 (1951)]. A.

539.132 : 539.11

2877. Nuclear quadrupole effects and electronic structure of molecules in the solid state. C. H. TOWNES AND B. P. DAILEY. *J. Chem. Phys.*, **20**, 35–9 (*Jan.*, 1952).

Measured nuclear quadrupole effects in solids are discussed, compared with nuclear quadrupole coupling in gases, and correlated to some extent with molecular structure in the solid state. The iodine crystal affords a good example of intermolecular interactions in the solid state. In this crystal, nuclear quadrupole effects combined with crystallographic information show two intermolecular covalent bonds per atom, each of about 9% importance. A.

539.132

2878. On the calculation of electronic levels in pyridine and the isomeric picolines. G. P. NORDHEIM AND H. SPONER. *J. Chem. Phys.*, **20**, 285–7 (*Feb.*, 1952).

The molecular orbital method was used for calculating electronic levels in pyridine and the picolines. The change of the benzene Coulomb integrals caused by the nitrogen atom in the ring and the CH_3 substitution is treated by introducing into the secular determinant perturbation parameters δ_k at the appropriate positions. Bonding and antibonding single-electron molecular orbitals are calculated neglecting the overlap integral and electronic repulsion. The average heights are determined for the four one-electron transitions corresponding to the fourfold degenerate level in benzene. By using the assumption that the centres of gravity of the actual singlets are proportional to these average heights, these centres of gravity are predicted for pyridine and the three picolines using two different perturbation parameters δ_N. The values for pyridine show satisfactory agreement with the experimental mean value 6·14 eV. A.

539.132

2879. The temperature dependence of the chlorine quadrupole coupling in solid benzene compounds. C. DEAN AND R. V. POUND. Letter in *J. Chem. Phys.*, **20**, 195–6 (*Jan.*, 1952).

Variations in resonance frequency among the compounds can be attributed to variation in Cl–C bond character. The discontinuity in *p*–Cl_2–benzene may be due to a phase change, the bond directions differing in the 2 phases. J. JACOBS

539.132

2880. Variations in absolute chemical shift of nuclear induction signals of hydroxyl groups of methyl and ethyl alcohol. J. T. ARNOLD AND M. E. PACKARD. Letter in *J. Chem. Phys.*, **19**, 1608–9 (*Dec.*, 1951).

Similar changes in the absolute chemical shift of proton nuclear induction signals due to the OH groups of methyl and ethyl alcohols are introduced by increasing temperature and by increasing dilution of the alcohol with CCl_4. W. R. ANGUS

539.132

2881. Chemical shift and field independent frequency modulation of the spin echo envelope. E. L. HAHN AND D. E. MAXWELL. Letter in *Phys. Rev.*, **84**, 1246–7 (*Dec.* 15, 19[illegible])

This is found[illegible] molecules in which there is one or more neighbouring nuclei which are (1) identical with the resonant one, but chemically non-equivalent, or (2) not identical. An empirical Hamiltonian operator for the system is suggested[illegible] in the case of two non-equivalent nuclei, which accounts for the properties and shape of the echo envelop[illegible] J. HUGHES

539.132

2882. Temperature dependent m[illegible]etic shielding in ethyl alcohol. U. LIDDEL AND N. F[illegible]AMSEY. Letter in *J. Chem. Phys.*, **19**, 1608 (*Dec.*, 19[illegible])

Alternative mechanisms for the t[illegible]perature dependence of the position of the weake[illegible] of the three proton resonances in ethyl alcohol are cussed, viz. effects of temperature on the associati[illegible] hydrogen angle vibrations and hindered rotations. [illegible]. R. ANGUS

539.132

2883. Erratum: Nuclear magnetic s[illegible]lding in fluorine and hydrogen compounds. H. S. [illegible]TOWSKY AND C. J. HOFFMAN. Letter in *J. Chem.* [illegible]*ys.*, **20**, 200 (*Jan.*, 1952). See Abstr. 433 (1952).

539.132

2884. Interactions between nuclear spi[illegible] in molecules. N. F. RAMSEY AND E. M. PURCE[illegible]. Letter in *Phys. Rev.*, **85**, 143–4 (*Jan.* 1, 1952).

Magnetic interaction between ea[illegible] nucleus and electron spin of its own atom, an[illegible] an exchange coupling of electronic spins should giv[illegible]n $I_1 . I_2$ interaction of correct magnitude. J. JACOBS

539.132 : 535.343

2885. The vibration-rotation energi[illegible] of molecules. H. H. NIELSEN. *Rev. Mod. Phys.*, 2[illegible]0–136 (*April*, 1951).

Mathematical. Vibration-rotation[illegible]ergy in 2nd-order approximation depends on q[illegible]ities related

to terms in the Hamiltonian operator of the molecule. It becomes possible to calculate this energy for a general polyatomic molecule. Application to particular types can be carried out if the normal co-ords. of harmonic vibrations for the model are determined. The relations assume J and K not too large and no resonance between close-lying frequencies. Then 2nd-order approximations prove sufficient. J. JACOBS

539.132

2886. Vibrational intensities. III. Carbon dioxide and nitrous oxide. D. F. EGGERS, JR AND B. L. CRAWFORD, JR. *J. Chem. Phys.*, **19**, 1554–61 (*Dec.*, 1951).

Experimental intensity measurements can be combined with known harmonic and anharmonic potential constants of molecules to determine the variation of dipole moment with displacement. A finite Taylor's series has been used for both potential energy and dipole moment. The effect on intensity of frequency variation over the band is included explicitly for both parallel and perpendicular bands as is Fermi resonance between several bands. Intensities of two fundamental and four combination bands in carbon dioxide were measured. A complete second-order perturbation treatment of intensities was carried out for several bands, and the possible relation of the results to resonance structures is mentioned. The relative importance of electrical and mechanical anharmonicity is indicated. Two cubic potential constants were determined for nitrous oxide from measured intensities, known rotational convergence, normal co-ordinates and bond distances. Using these constants a first-order intensity treatment was carried out for several combination bands. The intensities of three fundamental and three combination bands were measured. Discrepancies in measured rotational convergences are mentioned, and possible lines are suggested for further work on nitrous oxide. A.

539.132

2887. New developments in molecular orbital theory. C. C. J. ROOTHAAN. *Rev. Mod. Phys.*, **23**, 69–89 (*April*, 1951).

A vigorous formal development of the mathematical basis of MO theory. All electrons are included; as the molecular inner shell electron equations are very nearly identical with those of atomic inner shells, their contributions and interactions with valence electrons can be recognized. For excitation and ionization energies configurational MO's are used, and the effects of molecular symmetry is discussed. J. JACOBS

539.132 : 541.57

2888. The molecular orbital theory of chemical valency. IX. The interaction of paired electrons in chemical bonds. J. LENNARD-JONES AND J. A. POPLE. *Proc. Roy. Soc. A*, **210**, 190–206 (*Dec.* 20, 1951).

For Pt VIII, see Abstr. 3685 (1951). In previous parts the molecular orbital theory has been developed in a way which, while dealing satisfactorily with the interaction of electrons in different orbitals, is not adequate to describe the wave theory of two paired electrons in the same orbital. This paper is an attempt to improve this part of the theory. Most of the work is restricted to the problem of two electrons in the bond of a homonuclear diatomic molecule. The method is based on expansions of the wave function and the interelectronic repulsion term of the Hamiltonian over the irreducible representations of the symmetry group. A series of coupled equations are obtained for the terms of the wave-function expansion. These exact equations form a useful background against which to examine some approximate wave functions, including the simple molecular orbital function and the electron-pair function. Some approximate calculations on the H molecule indicate that inclusion of higher terms in the wave-function expansion substantially reduces the calculated electron repulsion energy. A.

539.132

2889. Bond orbitals and bond energy in elementary phosphorus. L. PAULING AND M. SIMONETTA. *J. Chem. Phys.*, **20**, 29–34 (*Jan.*, 1952).

A discussion of the relative stability of the P_4 molecule and black phosphorus is carried out, with use of hybrid *spd* bond orbitals. The amount of strain in the P_4 molecule, in which the bond angles are 60°, is calculated to be 22·8 kcal mole^{-1}. This value is shown to be compatible with thermochemical data; it corresponds to the value 51·3 kcal mole^{-1} for the bond energy of the normal P–P bond. A structure is proposed for red phosphorus and other allotropic forms of the element, and some of their properties are discussed in relation to their structure. A.

539.132

2890. The pyramidal B_5H_9 structure. G. H. DUFFY. Letter in *J. Chem. Phys.*, **20**, 194–5 (*Jan.*, 1952).

To avoid 3*d* orbitals, 4 effective bonds are formed from $2s$ $2p$ $2p_x$ $2p_y$ orbitals, one the B–H bond, the other 3 bonds linking the apical B to the 4 base ones. J. JACOBS

539.132

2891. Quantum mechanics and force-constants of the methane molecule and of deuteromethanes. M. A. KOVNER AND SH. E. TSIMRING. *Dokl. Akad. Nauk SSSR*, **79**, 949–52 (*No.* 6, 1951) *In Russian.*

For the C electrons forming the C–H bond, orthonormal linear combinations of $2s$ and $2p$ atomic functions are constructed which are energetically most favourable. For these wave functions the deviation of their axis of symmetry from the C–H tetrahedral direction is characterized by 2 "coeffs. of deviation." All 5 force constants and their dependence on Coulomb and exchange integrals are established using symmetry co-ordinates. One coeff. of deviation, being constant for all deuterated methanes, may be used as index of deformation of the electron shells. J. JACOBS

539.133

2892. The potential constants of ethane. G. E. HANSEN AND D. M. DENNISON. *J. Chem. Phys.*, **20**, 313–26 (*Feb.*, 1952).

The infrared and Raman data of light and heavy ethane (C_2H_6 and C_2D_6) have been re-examined for the purpose of determining as accurately as possible the potential constants of the ethane molecule. In order to fill in some of the gaps in the spectroscopic data, additional high resolution measurements have been made on the infrared spectrum of heavy ethane which have given more precise values for the active fundamental frequencies and zeta values. Resolution

of the fine structure associated with the parallel band ν_5^* has given the value of the large moment of inertia of C_2D_6, thus completing the information required for the spectroscopic determination of the dimensions of ethane. The data yield, C–C distance = 1·543 Å, C–H distance = 1·102 Å, H–C–C angle = 109° 37′, and H–C–H angle = 109° 19′. The twenty-two distinct potential constants compatible with the D_{3d} symmetry of ethane have been determined through their relationships to the normal frequencies and zeta values of C_2H_6 and C_2D_6. The normal frequencies have been obtained by addition of anharmonic corrections to the spectroscopically observed fundamental frequencies. These corrections were estimated by means of the known anharmonic corrections for methane and the conditions imposed by the Teller product rule. The fundamental frequencies and zeta values have been taken directly from the observed band centres and rotational spacings wherever possible. In the cases of resonance, the influence of the couplings were either calculated or estimated and the corresponding unperturbed values for the frequencies and zeta values selected. The potential function is determined first in terms of a set of simple symmetry co-ordinates, and then re-expressed in terms of valence co-ordinates to permit comparison of the valence force constants of ethane and methane. A.

539.133

2893. Force constants and calculated thermodynamic properties of nitrosyl fluoride. C. V. Stephenson and E. A. Jones. *J. Chem. Phys.*, **20**, 135–6 (*Jan.*, 1952).

The force constants for NOF were calculated using the Wilson FG Matrix method. Unique values could not be calculated, since the number of force constants exceeded the number of fundamental vibrations. However, upper and lower limits have been set for the force constants. The thermodynamic functions for NOF were calculated for temperatures ranging from 273·16°K to 1 500°K, using the rigid rotator, harmonic oscillator approximation. A.

539.133 : 535.343.4–14

The microwave spectrum of a slightly aspherical top—the structure and dipole moment of sulfuryl fluoride. *See Abstr.* 2622

539.133 : 535.343.4–14

Microwave spectra and molecular structures of POF_3, PSF_3, $POCl_3$, $PSCl_3$, SO_2F_2, ReO_3Cl. *See Abstr.* 2623–5

539.133 : 539.27

2894. The structure of the tetrachloroethylene molecule. I. L. Karle and J. Karle. *J. Chem. Phys.*, **20**, 63–4 (*Jan.*, 1952).

The equilibrium distances and average amplitudes of vibration have been determined for the molecule C_2Cl_4 by the analysis of quantitative electron diffraction data. The results are listed. A.

539.133 : 539.27

2895. An electron diffraction investigation of cyclooctatetraene and benzene. I. L. Karle. *J. Chem. Phys.*, **20**, 65–70 (*Jan.*, 1952).

The interatomic distances and their vibrational amplitudes have been determined for C_8H_8 and C_6H_6 by quantitative analysis of electron diffraction sector photographs. The D_{2d} tube configuration, with the oblique C–C bonds longer than the horizontal ones, has been confirmed for C_8H_8. The interatomic distances involving H atoms have been evaluated. A.

539.133

2896. Dipole moments derived from force constants and ionic refractions. C. K. Møller. *J. Chem. Phys.*, **20**, 203–4 (*Feb.*, 1952).

For simple hydrogen compounds an approximate formula is derived which correlates the dipole moments of the H-bonds with the corresponding stretching force constant, bond length and ionic refraction; the formula contains only a single adjustable parameter. A.

539.133

2897. Electric moments and structure: determination of the equilibrium configuration of the ortho-methoxybenzoate of methyl. Note on the rigidity of conjugated molecular systems. H. Lumbroso and P. Rumpf. *Bull. Soc. Chim. France*, **18**, 628–32 (*Sept.–Oct.*, 1951) *In French.*

Measurements were made of dipole moments of methyl-benzoates (*a*) methoxy-2 $\mu = 2{\cdot}64D$, (*b*) bromo-5 methoxy-2 $\mu = 2{\cdot}77D$, (*c*) nitro-5 methoxy-2 $\mu = 3{\cdot}74D$. These confirm the greater importance of the previously proposed configuration. Case (*c*) shows that the mixture of the 2 predominant configurations is detectably different here. The possibility of deformation of ortho-substituted methoxy-derivatives is discussed. J. JACOBS

539.133

2898. The physical properties of molecules in relation to their structure. I. Relations between additive molecular properties in several homologous series. H. J. Bernstein. *J. Chem. Phys.*, **20**, 263–9 (*Feb.*, 1952).

Relations between the additive physical properties of the substituted methanes, ethanes, ethylenes, benzenes and the acyclic saturated hydrocarbons have been derived assuming strict additivity for the contributions from non-bonded atoms as well as for the contributions from bonded atoms. A.

ATOMIC STRUCTURE . NUCLEUS ISOTOPES 539.15

539.152.1

2899. *K*-capture and special zones. M. A. Levitskaya and L. P. Rapoport. *Dokl. Akad. Nauk SSSR*, **79**, 953–5 (*No.* 6, 1951) *In Russian.*

Plots of the number of *K*-unstable isotopes and of the half-life against *Z* reveals certain favoured zones. It is suggested that these are correlated with nuclear shell structure through the radial distribution of the proton wave-functions. W. J. Swiatecki

539.152.1

2900. Rotational energy levels of an alpha-particle model for the beryllium and carbon isotopes. R. R. Haefner. *Rev. Mod. Phys.*, **23**, 228–37 (*July*, 1951).

Existing data on Be^8 and C^{12} energy levels (α–α scattering, energy spectrum of α's from Be^{8*} decay, $Be^{11} + p$ reaction; $Be^9(\alpha, n)C^{12}$ or C^{12*} reaction, also $N^{15}(p, \alpha)C^{12}(\gamma)C^{12*}$) are consistent with an α-particle

model using a simple interaction potential between the α's. The addition of a neutron with a *p*-wave function to the 2 or 3 α's produces models of Be^9 and C^{13} respectively. These are compared with experiment. W. J. SWIATECKI

539.152.1

2901. An asymmetric nuclear model. S. GALLONE AND C. SALVETTI. *Nuovo Cim.*, **8**, 970–6 (*Dec.*, 1951) *In Italian.* Also in *Phys. Rev.*, **84**, 1064–5 (*Dec.* 1, 1951).

An asymmetric nuclear model proposed by Rainwater [Abstr. 8911 (1950)] is here extended and discussed for the case of strong spin-orbit coupling and more general deformations. A.

539.152.1

2902. An energy level in Li^6. W. M. HARRIS. Letter in *Phys. Rev.*, **84**, 1249 (*Dec.* 15, 1951).

A 7 MeV proton beam was scattered through an enriched LiF target. A level of $2{\cdot}12 \pm 0{\cdot}05$ MeV was found. F. R. HOLT

539.152.1

2903. The hyperfine structure anomaly of the Rb isotopes. S. A. OCHS AND P. KUSCH. Letter in *Phys. Rev.*, **85**, 145 (*Jan.* 1, 1952).

New accurate atomic beam measurements gave $R = \Delta r^{87}/\Delta r^{85} = 2{\cdot}251413 \pm 0{\cdot}000005$, and this value, combined with Yasaitis and Smaller's measurement of the ratio μ^{87}/μ^{85} [see Abstr. 6390 (1951)] leads to $(R_{obs} - R_{calc})/R_{calc} = 0{\cdot}3501 \pm 0{\cdot}0006\%$, a value considerably in excess of that calculated by Bohr (0·26) on a simple nuclear model. L. PINCHERLE

539.152.1

2904. The classification of states of the nuclear *f*-shell. B. H. FLOWERS. *Proc. Roy. Soc. A*, **210**, 497–508 (*Jan.* 22, 1952).

Following the methods of Racah and of Jahn, the orbital states arising from the nuclear configuration f^n in Russell–Saunders coupling are classified by means of group theory. States are classified according to the irreducible representations of the permutation group, and of the rotation group in the seven-dimensional space spanned by the orbital states of a single *f*-particle. On the assumption of short-range attractive forces, this classification allows predictions regarding the ordering of levels in the *f*-shell; and, in particular, the lowest states of nuclei which contain only the simple f^n configuration (apart from closed shells) may be predicted as a function of the isotopic number. Numerical values of the Slater integrals for the *f*-shell with a Gauss interaction are given as a function of the range of the interaction. A.

539.152.1

2905. Limits of stability of the heavy elements and the effects of nuclear shell structure. P. S. GREIFINGER. *Phys. Rev.*, **85**, 253–6 (*Jan.* 15, 1952).

The systematics of β-decay, α-emission, and spontaneous fission are investigated in order: first, to determine the theoretical limits to the periodic table, and secondly, to examine the effects of nuclear shell structure on the end of the periodic table. Curves of β-stability and lifetimes against α-emission and spontaneous fission are drawn for the heaviest elements and extrapolated in order to yield information about the stability or form of instability of the transuranic elements. Nuclear shell structure is seen to be responsible for the stability of Th^{232} and U^{238} as well as the instability of the group of highly radioactive elements beginning with polonium. A.

539.152.2

2906. Nuclear spin and magnetic moment of rhodium $^{103}_{45}Rh$. H. KUHN AND G. K. WOODGATE. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1090–7 (*Dec.*, 1951).

The radiation from a hollow-cathode tube containing Rh was passed 4 times through an atomic beam of Rh. Absorption was found in 8 lines, 4 of which showed hyperfine structure doublets of separation $0{\cdot}023\ cm^{-1}$. The splitting could be ascribed to the ground state $4d^8\,5s\,{}^4F_{9/2}$. It was concluded with certainty that the spin of the Rh nucleus Rh^{103} has the value $I = \frac{1}{2}$. The relative intensities of the components show that the magnetic moment is negative. The observed splitting leads to an estimated value of $\mu = -0{\cdot}10$ nuclear magneton. The values of *I* and μ indicate a configuration $(5g_{9/2})^6 3p_{1/2}$ for the last 7 protons of the Rh nucleus in the Goeppert–Mayer model. A.

539.152.2 : 538.24

2907. On the possibility of aligning atomic nuclei by a method of double radioelectric resonance. A. KASTLER. *C.R. Acad. Sci.* [*Paris*] **233**, 1444–6 (*Dec.* 3, 1951) *In French.*

It is proved that the simultaneous application of an electronic and a nuclear magnetic resonance to a paramagnetic substance at liquid He temperatures may achieve considerable alignment of the nuclei, allowing a study of the anisotropy of nuclear reactions. L. PINCHERLE

539.152.2

2908. Interaction of nuclear resonance signals. G.-J. BÉNÉ, P.-M. DENIS AND R.-C. EXTERMANN. *Arch. Sci.*, **4**, 212–15 (*No.* 3, 1951) *In French.*

A description of transient phenomena occurring when the static field varies very slowly. L. PINCHERLE

539.152.2

2909. Amplitude of nuclear induction signals. G.-J. BÉNÉ, P.-M. DENIS AND R.-C. EXTERMANN. *Arch. Sci.*, **4**, 266–8 (*No.* 4, 1951) *In French.*

A study of the amplitude of proton resonance signals in solutions of $MnCl_2$ as a function of the concentration. Results are well interpreted by current theories. See also Abstr. 6384 (1951). L. PINCHERLE

539.152.2

2910. Contribution to the study of nuclear magnetic moments. G.-J. BÉNÉ. *Helv. Phys. Acta*, **24**, 367–88 (*No.* 4, 1951) *In French.*

Nuclear induction experiments using an air-cored electromagnet of 350 gauss gives $\gamma_F/\gamma_H = 0{\cdot}940760 \pm 0{\cdot}000050$ for a water solution of BeF_2, which is in agreement with corrected values [Abstr. 5202 (1950)] for iron-cored magnets. The resonance field for protons at a fixed frequency was the same to 1 in 10^3 for air- and iron-cored magnets, and no changes of ratio or frequency attributable to the interaction introduced by Stueckelberg [Abstr. 2702 (1948)] was observed. The homogeneity of the field is discussed in detail. D. H. WHIFFEN

539.152.2

2911. "Slow beats" in F^{19} nuclear spin echoes. E. G. McNeil, C. P. Slichter and H. S. Gutowsky. Letter in *Phys. Rev.*, **84**, 1245–6 (*Dec.* 15, 1951).

F^{19} spin echoes in the compounds BrF_5 and IF_5 exhibit slow beats which are interpreted as originating from an interaction among the F^{19} nuclei via a coupling with the nuclear magnetic shielding fields. It is shown to be the interaction which in steady-state observations of the F^{19} nuclear magnetic resonance in these compounds gives rise to a multiplet line structure. J. HUGHES

539.152.2

2912. Nutational resonance. H. C. Torrey. Letter in *Phys. Rev.*, **85**, 365–6 (*Jan.* 15, 1952).

When repeated radiofrequency pulses are applied to proton-containing liquids in a magnetic field, one would expect the nuclear resonance signals to be small when the off- and on-time of the pulses are short compared with the relaxation times. However, near resonance the signal was observed to maintain a relatively large value. A theory is given based on the Bloch equations. L. PINCHERLE

539.152.2

2913. Magnetic moments of even-odd nuclei. J. P. Davidson. *Phys. Rev.*, **85**, 432–4 (*Feb.* 1, 1952).

The deviations of nuclear magnetic moments from the Schmidt limits are interpreted in terms of a failure of L–S coupling, and a simple interpolation procedure is applied to compute the statistical weight of the components with $L = I + \frac{1}{2}$ and $L = I - \frac{1}{2}$. The results below odd N or $Z = 53$ are sufficiently regular to be used to compute the magnetic moments of several odd neutron nuclei. A.

539.152.2

2914. The spin and quadrupole moment of O^{17}. S. Geschwind, G. R. Gunther-Mohr and G. Silvey. *Phys. Rev.*, **85**, 474–7 (*Feb.* 1, 1952).

Measurements of the quadrupole splitting caused by the O^{17} nuclear spin in the $J = 1 \rightarrow 2$ transition of the $O^{17}C^{12}S^{32}$ pure rotational spectrum show that the spin of O^{17} is 5/2 and its quadrupole coupling constant is $-1{\cdot}32 \pm 0{\cdot}07$ Mc/s. From this coupling constant, the quadrupole moment of the O^{17} nucleus can be estimated as $Q = -5\times10^{-27}$ cm^2. O^{17} appears to fit the extreme single particle model of the nucleus exceptionally well. A.

539.152.2

2915. The nuclear magnetic resonance of titanium and arsenic. C. D. Jeffries, H. Loeliger and H. H. Staub. Letter in *Phys. Rev.*, **85**, 478–9 (*Feb.* 1, 1952).

$\nu(\mathrm{Ti})/\nu(\mathrm{H}) = 0{\cdot}05638 \pm 0{\cdot}00001$; $s(\mathrm{Ti}) = 7/2$ (probably the isotope 49, not 47); $\mu(\mathrm{Ti}) = -(1{\cdot}1022 \pm 0{\cdot}0003)$ n.m.; $\nu(\mathrm{As}^{75})/\nu(\mathrm{H}) = 0{\cdot}17129 \pm 0{\cdot}00003$; $s(\mathrm{As}^{75}) = 3/2$; $\mu(\mathrm{As}^{75}) = +(1{\cdot}4350 \pm 0{\cdot}0003)$ n.m. L. PINCHERLE

539.152.2

2916. The nuclear magnetic moment of Tc^{99}. H. Walchli, R. Livingston and W. J. Martin. Letter in *Phys. Rev.*, **85**, 479 (*Feb.* 1, 1952).

$\nu(\mathrm{Tc}^{99})/\nu(\mathrm{D}) = 1{\cdot}46628 \pm 0{\cdot}0001$; $s(\mathrm{Tc}^{99}) = 9/2$; $\mu(\mathrm{Tc}^{99}) = +(5{\cdot}6805 \pm 0{\cdot}0004)$ n.m. L. PINCHERLE

539.153

2917. The positronium fine structure. R. A. Ferrell. Letter in *Phys. Rev.*, **84**, 858–9 (*Nov.* 15, 1951).

A table is given of the numerical values of the fine structure of the energy levels. J. HUGHES

539.153

2918. Energy levels and transition probabilities in p^2 and p^4 configurations. R. H. Garstang. *Mon. Not. Roy. Astron. Soc.*, **111**, 115–24 (*No.* 1, 1951).

The energies of the levels of the configurations p^2 and p^4 are calculated, including the Hamiltonian terms arising from the interaction of the spin of one electron with the orbit of another and the interaction of the spins of pairs of electrons. The spin interaction parameters and unperturbed energies of the levels are determined empirically from observational spectroscopic data. Comparisons are made with parameters computed from self-consistent field wave functions where available. Revised transition probabilities are computed for the forbidden lines within the configuration p^2 for the ions C I, N II, O III, F IV and Ne V and within the configuration p^4 for the ions O I, F II and Ne III. A.

539.153

2919. On the calculation of the lowest energy level of helium. M. Simonetta and R. Bonelli. *Nuovo Cim.*, **8**, 813–16 (*Nov.*, 1951) *In Italian.*

The energy of the lowest triplet state of helium has been evaluated using the variation function: $1s_{Z'}(1)2s_{Z''}(2) - 2s_{Z''}(1)1s_{Z'}(2)$. The energy value obtained is $-4{\cdot}3322\ R_{He}hc$, for $Z' = 1{\cdot}991$ and $Z'' = 1{\cdot}497$. A.

539.153

2920. On the existence of solutions of the helium wave equation. T. Kato. *Trans Amer. Math. Soc.*, **70**, 212–18 (1951).

It is proved that the helium wave equation admits solutions, including that of the ground state. The main tool in the proof is the spectral theorem for a hypermaximal symmetric operator. MATHEMATICAL REVIEWS

539.153

2921. Wave function of ionized lithium. P. J. Luke, R. E. Meyerott and W. W. Clendenin. *Phys. Rev.*, **85**, 401–9 (*Feb.* 1, 1952).

A non-relativistic wave function for the $1s2s^3S$ state of singly ionized Li has been found by using an expansion of the function in Legendre polynomials of the cosine of the angle between the lines joining the electrons to the nucleus. Previous work had indicated that the distance dependent coefficient of the angle-independent term of the expansion predominates over the others. This made it possible to obtain an accurate function by computing to high precision an approximate value of the coefficient as a function of the distances of the electrons from the nucleus. The calculation of this function of the two distances was facilitated by the separability of the wave equation satisfied by the function. An additive correction to this function and also the distance dependent coefficients of higher-order Legendre polynomials, all of which were comparatively small, could then be calculated by relaxation and numerical variational

methods of less accuracy. Application of tests based on the virial theorem and Green's Theorem to the wave function were used as criteria of accuracy. The Ritz integral led to the energy value $-1{\cdot}135724\ RhcZ^2$, where R is Rydberg's constant for Li, Z is the atomic number, and h and c are Planck's constant and the velocity of light, respectively. This result compares favourably with the experimental value, corrected for the relativistic effect and nuclear motion, of $-1{\cdot}135722 \pm 0{\cdot}000025\ RhcZ^2$. The hyperfine structure integral $1+\varepsilon$ of Breit and Doermann was found to have the value $1{\cdot}06191 \pm 0{\cdot}00003$. A.

539.153

2922. Calculation of the *g*-factor of metallic sodium. Y. YAFET. Letter in *Phys. Rev.*, **85**, 478 (*Feb.* 1, 1952).

The effect of spin-orbit coupling on the electronic *g*-value expected in a spin resonance experiment on metallic Na was calculated using a sum of one-electron Hamiltonians and the sphere approximation of the cellular method. Result: $\Delta g = -3{\cdot}7\times10^{-4}\sin^2\theta_0$ (θ_0 = angle H, k), so that $g_{max} = g_{spin} + \Delta g \simeq 2{\cdot}0019$. L. PINCHERLE

539.153 : 535.332

2923. Fine structure of the hydrogen atom. III. W. E. LAMB, JR. *Phys. Rev.*, **85**, 259–76 (*Jan.* 15, 1952).

For Pt II, see Abstr. 3708 (1951). Provides a theoretical basis for analysis of precision measurements of the fine structure of H and D. It supplements the Bechert–Meixner treatment of a H atom by allowing for the presence of a magnetic field, as well as radiative corrections. The theory of hyperfine structure is somewhat extended. Stark effects due to motional and other electric fields are calculated. Possible radiative and non-radiative corrections to the shape and location of resonance peaks are discussed. Effects due to the finite size of the deuteron are also considered. A theory of the sharp resonances $2^2S_{\frac{1}{2}}(m_s=\frac{1}{2})$ to $2^2S_{\frac{1}{2}}(m_s=-\frac{1}{2})$ is given which leads to an understanding of the peculiar shapes of resonance curves shown in Pt II. In this connection, a violation of the "no-crossing" theorem of von Neumann and Wigner is exhibited for the case of decaying states. A.

539.153.4 : 535.331

2924. $L(L+1)$ correction in the spectra of the iron group. G. RACAH. Letter in *Phys. Rev.*, **85**, 381–2 (*Jan.* 15, 1952).

The $L(L+1)$ correction was first introduced empirically. It is shown that it follows from the hypothesis that the deviations from the Slater formulae in the n-electron configuration are the sum of the deviations relative to each pair of electrons. L. PINCHERLE

539.153.4 : 535.331

2925. The $L(L+1)$ correction to the Slater formulas for the energy levels. R. E. TREES. Letter in *Phys. Rev.*, **85**, 382–3 (*Jan.* 15, 1952).

From a discussion of term values relative to various configurations d^n it is concluded that it is likely that the $L(L+1)$ correction applies only to terms that are rational functions of the Slater parameters. L. PINCHERLE

539.155

2926. Masses of light nuclei from nuclear disintegration energies. H. A. WILSON. Letter in *Phys. Rev.*, **84**, 836 (*Nov.* 15, 1951).

Note about priority. [See Abstr. 8152 (1951)]. W. J. SWIATECKI

539.155.2

2927. Argon isotopes in natural gases. G. BOATO, G. CARERI AND M. SANTANGELO. *Nuovo Cim.*, **9**, 44–9 (*Jan.*, 1952).

The A isotopic composition has been measured in many Italian fumeroles and soffioni. A remarkable enrichment of A^{40} has been found, certainly due to K^{40} decay in the earth's interior. With the help of these data, the problem of the origin of atmospheric A is considered. A.

539.155.2

2928. The ideal equipment for the separation of isotopes. C. MARCHETTI AND M. SILVESTRI. *Nuovo Cim.*, **9**, 97–104 (*Feb.*, 1952) *In Italian.*

The cascade for separating isotopes without mixing inefficiency is studied. Conclusions are drawn which can be used to check the efficiency of real cascades against this standard of maximum efficiency physically attainable. A.

539.155.2 : 537.534.72

Mass spectrometry. *See Abstr.* 2761

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16

2929. Isotope catalogue on punched cards. J. M. A. LENIHAN. Letter in *Brit. J. Appl. Phys.*, **3**, 29 (*Jan.*, 1952).

539.16

2930. On the radioactivity of Vesuvian lava. F. BACHELET, M. FERRETTI SFORZINI AND F. IPPOLITO. *Nuovo Cim.*, **8**, 851–6 (*Nov.*, 1951) *In Italian.*

Some preliminary results on the photographically recorded radioactivity of differently aged samples of Vesuvian lava are reported and discussed. A.

539.16.08 : 537.542

A new automatic radioassayer. *See Abstr.* 2780

539.162

2931. Beta disintegration energies, magic numbers and the missing elements 43, technetium and 61, promethium. H. E. SUESS AND J. H. D. JENSEN. *Ark. Fys.*, **3**, 577–84 (*Paper* 37, 1951) *In German.*

The plots of β^+, β^- and K-capture energies against N and $(N-Z)$ reveal discontinuities of ~0·7–1·8 MeV for $N = 20$, 28, 50, 82 and ~0·6 MeV for $Z = 20$, 28, 50. Changes of slope in this energy surface can be correlated with discontinuities in the Coulomb energy depending on whether a high or low l proton shell is being filled, which influences the radial charge distribution. The pairing energies of protons or neutrons are found to be smallest after a closed proton or neutron shell. The instability of the elements 43 and 61 and of the odd mass isotopes of $Z = 18$, 58 can be deduced from the plots. W. J. SWIATECKI

539.163

2932. Possible natural radioactivity of neodymium. G. I. MULHOLLAND AND T. P. KOHMAN. Letter in *Phys. Rev.*, **85**, 144–5 (*Jan.* 1, 1952).

Failure to detect activity with a large proportional counter sets upper limits of 0·003 betas and 0·02 alphas per sec per gm. J. J. WILKINS

539.163

2933. Disintegration of the ground-state Sr^{85} and metastable energy level of 514 keV in Rb^{85}. W. S. EMMERICH AND J. D. KURBATOV. Letter in *Phys. Rev.*, **85**, 149–50 (*Jan.* 1, 1952).

No evidence was found for Rb^{85} states other than a metastable 514 ± 3 keV state, having $T(\frac{1}{2}) > 1\ \mu$sec, $\alpha_K = 0{\cdot}7\%$ and a K/L conversion ratio of 12 ± 3. J. J. WILKINS

539.163.1

2934. An accurate measurement of the periods of some radioelements. J. TOBAILEM. *C.R. Acad. Sci.* [*Paris*] **233**, 1360–2 (*Nov.* 26, 1951) *In French.*

A balanced pair of ionization chambers was used, one containing a standard source (Ra), the other the source to be measured. The values obtained for the $\frac{1}{2}$-lives were: Fe^{59}: $47{\cdot}1 \pm 0{\cdot}5$ day; Co^{60}: $5{\cdot}27 \pm 0{\cdot}07$ yr; Ga^{67}: $77{\cdot}9 \pm 0{\cdot}3$ hr; Rn: $3{\cdot}825 \pm 0{\cdot}005$ day. A. O. STANESBY

539.163.1

2935. Search for long-lived Nb^{94}. R. E. HEIN, C. M. FOWLER AND R. H. MCFARLAND. Letter in *Phys. Rev.*, **85**, 138–9 (*Jan.* 1, 1952).

This was unsuccessful, indicating a minimum half-life of 5×10^4 years. J. J. WILKINS

539.163.1

2936. Lifetime of an excited state of $_{66}Dy^{160}$ and upper limits for some other nuclei. F. K. MCGOWAN. Letter in *Phys. Rev.*, **85**, 142 (*Jan.* 1, 1952).

A lifetime of $(1{\cdot}8 \pm 0{\cdot}2) \times 10^{-9}$ sec was found, by delayed coincidences, from a Tb^{160} source. Half-life limits found were: Te^{123}, 1·0; Te^{125}, 2·0; Ho^{165}, 0·8; Hg^{198}, 0·4; and Tl^{203}, $0{\cdot}4 \times 10^{-9}$ sec. Similar apparatus was described earlier [Abstr. 2956 (1951)]. F. R. HOLT

539.163.1

2937. An investigation of the double beta-decay of $_{50}Sn^{124}$. M. I. KALKSTEIN AND W. F. LIBBY. Letter in *Phys. Rev.*, **85**, 368–9 (*Jan.* 15, 1952).

β-coincidences from the possible double β-decay of Sn^{124} were sought in a sample of SnO_2 enriched in Sn^{124} (95%), using a double screen-wall counter protected from cosmic radiation by a system of counters in anti-coincidence. The $\frac{1}{2}$-life is $> 2 \times 10^{17}$ yr. It is suggested that the lower value ($4–9 \times 10^{15}$ yr) of Fireman [Abstr. 2672 (1949)] may have been due to irregularities in the sample thicknesses, or to β-contamination. A. O. STANESBY

539.163.2

2938. Evidence for the natural radioactivity of indium. S. G. COHEN. Letter in *Bull. Res. Coun. Israel*, **1**, 116–17 (*March*, 1951).

Activity was sought in In, whose naturally occurring isotopes In^{113} and In^{115} are both members of isobaric pairs; evidence was obtained of a β-activity of a few hundred keV, indicating the decay of In^{115} to Sn^{115} with a $\frac{1}{2}$-life of $\sim 10^{14}$ yr. In^{113} may also decay by L-capture with a $\frac{1}{2}$-life of $\sim 10^{12}$ yr, but evidence for this is not conclusive; the $\frac{1}{2}$-life for K-capture is $> 10^{14}$ yr. A. O. STANESBY

539.163.2

2939. The decay of Co^{61}. L. A. SMITH, R. N. H. HASLAM AND J. G. V. TAYLOR. Letter in *Phys. Rev.*, **84**, 842–3 (*Nov.* 15, 1951).

Measurements of the decay of Co^{61} over 10 $\frac{1}{2}$-lives gave a $\frac{1}{2}$-life of $99{\cdot}0 \pm 0{\cdot}3$ min. The β-spectrum is double, with end-points at $1{\cdot}42 \pm 0{\cdot}02$ {$(55 \pm 10)\%$} and $1{\cdot}00 \pm 0{\cdot}02$ MeV; there is a γ-ray of $\sim 0{\cdot}5$ MeV. A. O. STANESBY

539.163.2

2940. Francium: element 87. M. PEREY. *Bull. Soc. Chim. France*, **18**, 779–85 (*Nov.–Dec.*, 1951) *In French.*

1·2% of the atoms of Ac disintegrate with emission of an α-particle to give AcK. This natural radioelement is the only known natural isotope of element 87 and has been given the name Francium. Several artificial isotopes have been subsequently discovered. AcK gives a continuous β-spectrum of E_{max} 1 200 keV and a γ-ray of 95 keV. The chemical properties are closer to those of Cs than to Rb and the other alkalis. A.

539.163.2

2941. A further study of the natural activity of lanthanum. R. W. PRINGLE, S. STANDIL, H. W. TAYLOR AND G. FRYER. Letter in *Phys. Rev.*, **84**, 1066–7 (*Dec.* 1, 1951).

Following Pringle *et al.* [Abstr. 6700 (1950)], further results show γ's of 535 ± 14, 807 ± 15 and $1\,390 \pm 30$ keV from La^{138}. The half-life is $2{\cdot}0 \times 10^{11}$ years. A decay scheme is suggested. F. R. HOLT

539.163.2

2942. Coincidence studies in the decay of La^{140}. B. L. ROBINSON AND L. MADANSKY. Letter in *Phys. Rev.*, **84**, 1067–8 (*Dec.* 1, 1951).

Experiments using proportional scintillation counters showed coincidences between the 2·26 MeV β-ray and the 1·60 MeV γ-ray, and between the 0·82 and 1·60 MeV γ-rays. A partial decay scheme is suggested. A. O. STANESBY

539.163.2

2943. The radioactive decay of Ca^{41}. F. BROWN, G. C. HANNA AND L. YAFFE. Letter in *Phys. Rev.*, **84**, 1243–4 (*Dec.* 15, 1951).

The characteristic K X-rays of K were detected from a sample of Ca^{41} produced by neutron irradiation of CaO samples, indicating the decay of Ca^{41} by K-capture, with a $\frac{1}{2}$-life of $(1{\cdot}2 \pm 0{\cdot}4) \times 10^5$ yr. A. O. STANESBY

539.163.2

2944. The radiations of RaD. R. C. BANNERMAN AND S. C. CURRAN. Letter in *Phys. Rev.*, **85**, 134–5 (*Jan.* 1, 1952).

Measurements of coincidences between the β- and hardest (46·7 keV) γ-rays of RaD, using proportional scintillation counters, gave the max. energy of the β-spectrum as 18 ± 2 keV. A decay scheme is suggested: at least one of the intermediate energy levels of RaE is probably metastable. A. O. STANESBY

539.163.2

2945. Radioactive Pm^{148} and Pm^{150}. J. K. LONG AND M. L. POOL. Letter in *Phys. Rev.*, **85**, 137 (*Jan.* 1, 1952).

Oxides of enriched Nd isotopes were irradiated with 6 MeV protons. A β^- activity ($1{\cdot}7 \pm 0{\cdot}1$ and $0{\cdot}6 \pm 0{\cdot}1$ MeV, with a γ-ray of $\sim 0{\cdot}54$ MeV) of $\frac{1}{2}$-life 48 days was assigned to Pm^{148} and a β^- activity ($2{\cdot}4 \pm 0{\cdot}2$ MeV) of $\frac{1}{2}$-life 2·7 hr to Pm^{150}.

A. O. STANESBY

539.163.2

2946. The decay series Nd^{140}–Pr^{140}–Ce^{140}. C. I. BROWNE, J. O. RASMUSSEN, J. P. SURLS AND D. F. MARTIN. Letter in *Phys. Rev.*, **85**, 146–7 (*Jan.* 1, 1951).

The β^+ ($2{\cdot}32 \pm 0{\cdot}02$ MeV) from Pr^{140}, an Auger electron ($28{\cdot}9 \pm 0{\cdot}5$ keV) and the γ- and X-ray spectra were investigated with a double-focusing β-spectrometer, a bent crystal X-ray spectrometer and scintillation γ-spectrometer. The ratio K/β^+ for Pr^{140} is deduced to be $1{\cdot}0 \pm 0{\cdot}1$. The data support an S_1 ground state for Pr^{140}. W. J. SWIATECKI

539.163.2

2947. The isomeric transition in Ge^{77}. A. C. G. MITCHELL AND A. B. SMITH. Letter in *Phys. Rev.*, **85**, 153–4 (*Jan.* 1, 1952).

Investigations of β- and γ-ray spectra lead to the conclusions that Ge^{77} has a $G_{7/2}$ ground-state configuration (half-life 12 hr) and a 380 ± 20 keV $P_{1/2}$ isomeric state ($\sim$1 minute half-life). J. J. WILKINS

539.163.2

2948. Further work on heavy collateral radioactive chains. W. W. MEINKE, A. GHIORSO AND G. T. SEABORG. *Phys. Rev.*, **85**, 429–31 (*Feb.* 1, 1952).

The half-life of Ac^{222} has been determined and an upper limit has been set for the half-life of Pa^{225}. An additional short-lived chain collateral to the actinium ($4n + 3$) natural radioactive family has also been partially identified. This chain decays as follows: $U^{227} \rightarrow Th^{223} \rightarrow Ra^{219} \rightarrow Em^{215} \rightarrow Po^{211} \rightarrow Pb^{207}$. A.

539.163.2 : 539.166

2949. Order of gamma-ray emission in the decay of In^{111}. M. M. MILLER, C. H. PRUETT AND R. G. WILKINSON. Letter in *Phys. Rev.*, **84**, 849–50 (*Nov.* 15, 1951).

Measurements of delayed coincidences between the 2 consecutive γ-rays emitted by In^{111} showed directly that the 247 keV γ-ray is delayed with respect to the one of 172 keV, in agreement with previous, less direct experiments [see also Abstr. 6418 (1951)].

A. O. STANESBY

539.164.7 : 537.534.74

2950. Alpha-alpha scattering. C. H. BRADEN, S. M. CARTER AND A. G. FORD. Letter in *Phys. Rev.*, **84**, 837 (*Nov.* 15, 1951).

2·2 cm Hg of He were used, with α's of $20{\cdot}4 \pm 1{\cdot}0$ MeV. The differential scattering cross-sections, at 60° and 90° c. of m. angles, were 0·086 and 0·14 ($\pm 5{\cdot}5\%$) barns/sterad. respectively. F. R. HOLT

539.164.7 : 537.534.74

2951. Scattering of 30-MeV alpha-particles by helium. E. GRAVES. Letter in *Phys. Rev.*, **84**, 1250–1 (*Dec.* 15, 1951).

Scattered α's were detected with a double proportional counter in a 2 ft dia. scattering chamber filled with He at 0·5 or 1 atm. Results agreed with theory, but at 11·6° a 40% increase in results at 1 atm. was found. The absolute differential cross-section at $83{\cdot}2°$ is $(2{\cdot}8 \pm 0{\cdot}7) \times 10^{-26}$ cm²/steradian. F. R. HOLT

539.165

2952. The beta-ray spectra of Tm^{170} and RaE. S. NAKAMURA, M. UMEZAWA AND H. TAKEBE. Letter in *Phys. Rev.*, **84**, 865–6 (*Nov.* 15, 1951).

For Tm^{170} good agreement is obtained with experiment if the β-transition is taken as first-forbidden, with either tensor or vector interaction. A re-investigation of the RaE spectrum, assumed first-forbidden, shows that the interaction corrections still cannot produce agreement with theory. A. O. STANESBY

539.165

2953. The β spectrum of sulphur 35 by the method of nuclear emulsions. F. GILLAIN. *Ann. Soc. Sci. Brux.* (*Sér.* 1) **65**, 135–41 (*Dec.*, 1951) *In French.*

The plates used were treated to reduce background. They contained a thin layer of the sulphur in colloidal form as a sandwich between two nuclear emulsions. The "foil path" of the tracks was measured with a microscope. The method appears very suitable for extremely weak activities, as long exposures can be given, and an approximate spectrum obtained.

F. R. HOLT

539.165

2954. Forbidden beta spectra of Sb^{124} and I^{124}. L. M. LANGER. Letter in *Phys. Rev.*, **84**, 1059 (*Dec.* 1, 1951).

Short comment on Abstr. 495 (1952).

539.165

2955. The beta-spectrum of La^{141}. R. B. DUFFIELD AND L. M. LANGER. Letter in *Phys. Rev.*, **84**, 1065–6 (*Dec.* 1, 1951).

The β-spectrum of fission-product La^{141} was examined in a lens spectrometer and found to consist of two components, 95% with an end-point of $2{\cdot}43 \pm 0{\cdot}03$ MeV and 5% with $0{\cdot}91 \pm 0{\cdot}04$ MeV. A γ-radiation of 1·3–1·6 MeV was observed with a scintillation spectrometer and appeared to be in coincidence with the lower β-group. L. R. SHEPHERD

539.165 : 539.166

2956. Beta-gamma angular correlation in the decay of I^{126} and K^{42}. D. T. STEVENSON AND M. DEUTSCH. Letter in *Phys. Rev.*, **84**, 1071 (*Dec.* 1, 1951).

Further application of the methods of Abstr. 8937 (1951). A. O. STANESBY

539.166

2957. Angular distribution of γ-radiation from polarized nuclei. N. R. STEENBERG. Letter in *Phys. Rev.*, **84**, 1051–2 (*Dec.* 1, 1951).

This is calculated for a cascade of γ-rays from an oriented γ-emitting nucleus and to a cascade of γ-rays following a β-emission from an oriented γ-emitting nucleus. J. HUGHES

539.166

2958. The decay of Bi^{207}. M. A. GRACE AND J. R. PRESCOTT. Letter in *Phys. Rev.*, **84**, 1059 (*Dec.* 1, 1951).

The γ-radiation of Bi^{207} was examined with a scintillation counter. The 2 γ-rays of 0·565 and 1·063 MeV are equal in intensity (within exptl. error) and coincidence measurements showed that at least

half of the γ-rays are in cascade. The results are consistent with the energy level assignments of Goldhaber and Sunyar [Abstr. 8894 (1951)]. A. O. STANESBY

539.166

2959. Connection between γ–γ and internal conversion angular correlations. J. W. GARDNER. Letter in *Phys. Rev.*, **85**, 137–8 (*Jan.* 1, 1952).

539.166

2960. Classification of the γ-radiation of Hf^{177}. F. K. MCGOWAN, E. D. KLEMA AND P. R. BELL. Letter in *Phys. Rev.*, **85**, 152–3 (*Jan.* 1, 1952).

Measurements of γ–γ angular correlation and *K*-shell internal conversion coefficients indicated a dipole-quadrupole cascade. J. J. WILKINS

539.166

2961. Transition energy determination for orbital capture. P. R. BELL, J. M. JAUCH AND J. M. CASSIDY. *Science*, **115**, 12–13 (*Jan.* 4, 1952).

A new method using the maximum in the continuous "internal γ-ray bremsstrahlung" spectrum to determine the transition energy analogously to the β-decay Fermi plot. Applied to Fe^{55} (using a scintillation spectrometer) it gives 206 ± 20 keV in good agreement with Stelson and Preston [Abstr. 8233 (1951)]. W. J. SWIATECKI

539.166 : 537.542

2962. Resolution of the scintillation spectrometer. A. W. SCHARDT AND W. BERNSTEIN. Letter in *Rev. Sci. Instrum.*, **22**, 1020–1 (*Dec.*, 1951).

The resolution of a counter with $\frac{1}{2}$ in cube of NaI–Tl for γ-rays between 5·8 keV and 1·3 MeV is studied. In low-energy regions resolution depends on the number of photoelectrons per scintillation. Relatively poor resolution at higher energies is attributed to non-uniform sensitivity of the photocathode of the multiplier. G. F. J. GARLICK

539.166 : 537.542

2963. Studies in the linearity of a scintillation gamma ray spectrometer. V. O. ERIKSEN AND G. JENSSEN. Letter in *Phys. Rev.*, **85**, 150 (*Jan.* 1, 1952).

Linearity is observed between γ-ray energy and scintillation pulse intensity for a NaI–Tl crystal over the range 0·05–0·5 MeV. G. F. J. GARLICK

539.166.08 : 541.15

Gamma-ray dosimetry with polyvinyl-chloride films. *See Abstr.* 3082

539.166.74

2964. Radiative corrections to Compton scattering. L. M. BROWN AND R. P. FEYNMAN. *Phys. Rev.*, **85**, 231–44 (*Jan.* 15, 1951).

Corrections of order e^6 to the differential cross-section for Compton scattering of unpolarized radiation by electrons are computed. The results for corrections ascribable to virtual photons are finite, relativistically invariant, and valid at all energies, but contain a term which depends logarithmically on an assumed small photon mass λ. A cross-section of the same order has also been obtained for double Compton scattering in which one of the emitted photons has an energy small compared to the rest mass of the electron (with the electron initially at rest). This contains a term depending on $\ln \lambda$ which exactly compensates the similar term arising from virtual quanta in all observable cases. Approximations for low and high energies, as well as numerical results, are given. These disagree with results obtained previously by Schafroth. A.

539.166.75

2965. The absorption of gamma-rays from Co^{60}. S. SHIMIZU, T. HANAI AND S. OKAMOTO. *Phys. Rev.*, **85**, 290–4 (*Jan.* 15, 1952).

Measurements of the absorption of γ-rays from Co^{60} (1·17 and 1·33 MeV) have been made in 27 elements. In order to exclude the errors due to secondary radiations which might be produced in neighbouring objects and in the absorbers, particular precautions were taken with respect to the geometrical arrangement of apparatus. The absorption coefficients measured for the elements whose atomic numbers are less than $_{52}$Te show reasonable agreement with those calculated according to existing theories. However, it is noted that the results with $_{73}$Ta, $_{74}$W, $_{78}$Pt, $_{79}$Au, $_{80}$Hg and $_{81}$Tl are 3% to 5·5% less than the theoretical values. It seems improbable that the disagreements observed in these elements may be assigned to experimental causes. If the entire deviation were assigned to inaccuracy in theoretical knowledge, it would be reasonable to attribute it to some insufficiency in the Klein–Nishina theory of the Compton effect for this energy of γ-rays. But further investigation should be undertaken to ascertain the fact. A.

539.166.83

2966. Measurements of some *K*-shell internal conversion coefficients. F. K. MCGOWAN. Letter in *Phys. Rev.*, **85**, 151–2 (*Jan.* 1, 1952).

Gamma-ray to *K* X-ray intensity ratios have been measured for Dy^{160}, Ho^{165}, Er^{166} and Yb^{170}, using a NaI scintillation spectrometer. J. J. WILKINS

539.166.831

2967. Influence of the chemical state on the lifetime of an isomer. K. T. BAINBRIDGE, M. GOLDHABER AND E. WILSON. Letter in *Phys. Rev.*, **84**, 1260–1 (*Dec.* 15, 1951).

The decay constants of 3 chemically distinct states of Tc^{99*} (metal, sulphide and pertechnetate) were compared using balanced ionization chambers and were in the ratios $1 : 1{\cdot}00031 \pm 0{\cdot}00012 : 1{\cdot}0030 \pm 0{\cdot}00010$ resp. (see also abstract following). A. O. STANESBY

539.166.831

2968. The effect of chemical combination on the internal conversion in Tc. J. C. SLATER. Letter in *Phys. Rev.*, **84**, 1261–2 (*Dec.* 15, 1951).

A discussion which seeks to show that the observed (preceding abstract) variation of decay constant of the isomer Tc^{99*} with its chemical state is not unreasonable theoretically. A. O. STANESBY

539.167.3

2969. Carrier-free radioisotopes from cyclotron targets. XXIV. Preparation and isolation of $Ir^{188, 190, 192}$ from osmium. H. R. HAYMOND, W. M. GARRISON AND J. G. HAMILTON. Letter in *J. Chem. Phys.*, **20**, 199–200 (*Jan.*, 1952).

For Pt XXIII, see Abstr. 514 (1952).

539.167.3

2970. Carrier-free radioisotopes from cyclotron targets. XXV. Preparation and isolation of $Au^{195, 196, 198, 199}$ from platinum. J. D. GILE, W. M. GARRISON AND J. G. HAMILTON. Letter in *J. Chem. Phys.*, **20**, 339–40 (*Feb.*, 1952).

539.167.3 : 621.315.211.4 : 621.317.39

2971. Some industrial applications of radioelements made at the Commissariat à l'Energie Atomique. J. GUERON. *Nucleonics*, **9**, 53–9 (*Nov.*, 1951).

Experiments using radioactive tracers to detect leakage of water into undersea cables, underground telephone cables and through welded seams in tanks and investigating the rate of air renewal in rooms are outlined. A radioactive falling ball viscometer, in which the passage of the ball (activated with Co^{60}) past two fixed levels, is detected by counters behind lead slits, is described. Some preliminary experiments on tracing the passage of water through soils and rocks are discussed. L. R. SHEPHERD

NUCLEAR REACTIONS 539.17

539.172

2972. Capture of π-particles by deuterons. I. POMERANCHUK. *Dokl. Akad. Nauk SSSR*, **80**, 47–8 (*No.* 1, 1951) *In Russian.*

Estimates of the cross-section for the process $\pi^- + D \rightarrow n + n + \pi^\circ$ show that it is sensitive to the relative parities of π^- and π°. The cross-section for $\pi^- + D \rightarrow n + n + \gamma$ is also given. W. J. SWIATECKI

539.172

2973. Meson reactions in hydrogen and deuterium. R. E. MARSHAK. *Rev. Mod. Phys.*, **23**, 137–46 (*April*, 1951).

Slow and fast π-meson reactions critically reviewed: the observed competing reactions $\pi^- + p \rightarrow n + \gamma$ or $+\pi^\circ$; their relative probabilities; the masses of π^- and π°. Results of theoretical calculations for all types of π^- and π° mesons and couplings. The 3 reactions: $\pi^- + d \rightarrow n + n$ or $n + n + \gamma$ or $n + n + \pi^\circ$; selection rules, theoretical and experimental γ spectrum. Fast π reactions: $\pi^- + p \rightarrow n + \pi^\circ$, $\pi^\pm + p \rightarrow p + \pi^\pm$, $\pi^+ + d \rightarrow p + p$ (and reverse), $\pi^+ + d \rightarrow d + \pi^+$, $\pi^+ + d \rightarrow p + n + \pi^+$, $\pi^+ + d \rightarrow p + p + \pi^\circ$; theoretical cross-sections as functions of energy. W. J. SWIATECKI

539.172

2974. *K*-capture of the μ-meson. P. BUDINI. *Nuovo Cim.*, **8**, 901–8 (*Dec.*, 1951) *In Italian.*

The reaction of negatively charged mesons with atomic nuclei is examined on the hypothesis that the process involved is a transition (described) with pseudoscalar mesons: only the pseudoscalar term of the interaction is considered. Contrary to what had been foreseen, the probability of the reaction is, in this case also, proportional, for the lightest nuclei, to the fourth power of the atomic number. The influence of the pseudoscalar theory on the problem of nuclear excitation is studied. A.

539.172

2975. The disintegration of light nuclei by meson capture. A. C. CLARK AND S. N. RUDDLESDEN. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1064–78 (*Dec.*, 1951).

The disintegration by π^--meson capture of the elements He and C is discussed. Two types of meson theory, scalar and pseudoscalar, are considered. The relative probabilities of the various modes of disintegration of He are calculated and the energy spectra of the most likely one, viz. proton emission, are shown. The disintegration of C into two α-particles and one singly charged particle is considered, using a simple α-particle model. The energy spectra and angular correlations of the α-particles obtained by a direct transition and by a transition via an excited state of ^8Be are compared. A.

539.172

2976. Fast protons from the capture of π^- mesons in photographic emulsions. F. L. ADELMAN. *Phys. Rev.*, **85**, 249–53 (*Jan.* 15, 1952).

The spectrum of fast protons from 1 631 π^--meson absorptions in Ilford G-5 and C-2 emulsions has been studied. It has been found that $(16{\cdot}1 \pm 1{\cdot}8)\%$ of all π^--meson absorptions are accompanied by protons of energy greater than 20 MeV, and that $(9{\cdot}5 \pm 1{\cdot}3)\%$ of all absorptions are accompanied by protons of energy greater than 30 MeV. The proton energies were estimated by grain counting in comparison with π^--mesons of known residual range. Allowance was made for the variation of grain density with position and depth in the emulsion. The energy spectrum is fairly flat from 30–70 MeV, but only three events were found above 70 MeV. Examination of stars from which the fast protons were emitted shows more prongs ejected opposite to the direction of the fast proton than are accounted for by evaporation from a recoiling nucleus. The energy spectrum favours the capture of the meson by a proton, with the recoil momentum taken by a small, variable number of nucleons. Furthermore, the evidence suggests that the low energy star prongs result from knock-on collisions of the primary nucleons with other nucleons inside the nucleus. A.

539.172

2977. Nuclear disintegration by positron-*K* electron annihilation. R. D. PRESENT AND S. C. CHEN. *Phys. Rev.*, **85**, 447–51 (*Feb.* 1, 1952).

A new process for the annihilation of fast positrons is discussed, in which a positron with insufficient energy to excite or disintegrate a nucleus by collision, annihilates a *K*-electron of an atom with subsequent excitation or disintegration of its nucleus. If the positron energy is close to threshold for the process, competition from two-quanta annihilation does not occur. The process is of first order and, apart from the occurrence of negative energy states, is the reverse of internal conversion. The cross-section can be factored into a cross-section for annihilation with emission of a photon converging on the nucleus × a probability for nuclear disintegration. In the electric dipole case, the latter is just the ratio of the photodisintegration cross-section to the *P*-wave blackbody absorption cross-section of the nucleus. The photodisintegration cross-section is taken from experiment. The annihilation cross-section in light elements has been calculated in the Born approximation using the complete retarded interaction corresponding to converging spherical waves of electric dipole radiation (the nucleus acts as a sink for these waves, in addition to conserving momentum). For large incident energy of the positron ($\gg mc^2$) the difference between positive and negative energy states

can be neglected approximately, and the cross-section obtained by detailed balancing from the internal conversion coefficient. In so far as accurate values of the latter are known in the proper energy range for high atomic numbers Z, the annihilation cross-section for very fast positrons can be obtained to a good approximation for the same values of Z. Numerical estimates have been made for the disintegration of Be^9 with emission of a neutron and also for the disintegration of U^{238} resulting in nuclear fission. The total annihilation-disintegration cross-sections near the threshold in these two cases are $\sim 10^{-34}$ cm^2 and $\sim 10^{-31}$ cm^2, respectively. The total cross-section for an annihilation-excitation of In^{115} into an activation level for the metastable state resulting in the formation of a nuclear isomer, is found to be $\sim 10^{-26}$ cm^2. A.

539.172 : 537.591.8

Nuclear reactions due to cosmic rays. *See Abstr.* 2818–23

539.172.11 : 539.185

2978. Energy levels in C^{12} from $Be^9(\alpha,n)C^{12}$. W. H. Guier, H. W. Bertini and J. H. Roberts. *Phys. Rev.*, **85**, 426–8 (*Feb.* 1, 1952).

A thin Po source and thin Be target have been used to investigate energy states in C^{12}. The neutron spectrum was determined from proton tracks in Eastman NTA emulsions. By investigating the neutrons emitted in the forward and backward directions, neutrons associated with the transition to the ground state of C^{12} were detected, and excited levels in C^{12} were identified at 4·2 and 7·5 MeV above the ground state. A.

539.172.13 : 539.153

2979. Energy spectrum of protons produced in the reaction $C^{12}(d,p)C^{13}$, and its relation with the possible excited states of C^{13}. II. J. Catala de Alemany and F. Senent Perez. *An Real. Soc. Esp. Fis y Quim. A*, **47**, 225–30 (*Sept.–Oct.*, 1951) *In Spanish.*

For Pt I, see Abstr. 4716 (1951). Following the proton tracks examination, in C2 emulsions, for the above-mentioned nuclear reaction, the existence of the two lower levels in C^{13} (3·091 and 3·88 MeV) is confirmed, in good agreement with other investigators' results. A.

539.172.13

2980. The production of light nuclei by high energy proton bombardment of medium weight elements. D. H. Greenberg and J. M. Miller. Letter in *Phys. Rev.*, **84**, 845–6 (*Nov.* 15, 1951).

Thin Cu targets were bombarded with 370 MeV protons. The cross-sections in barns for the production of C^{11}, F^{18} and Na^{24} were each 3×10^{-5}, and for K^{42}, 5×10^{-5}. These results are compared with other data. F. R. Holt

539.172.13

2981. A search for gamma-rays from the 4·8-MeV level in Li^7. H. E. Gove. Letter in *Phys. Rev.*, **84**, 1059 (*Dec.* 1, 1951).

Comparison of the γ-radiation emitted during the bombardment of C^{12} and Li^7 with 8 MeV protons showed that the 4·8 MeV excited state of Li^7 does not decay by γ-emission, but presumably by particle emission (into $He^4 + H^3$?) A. O. Stanesby

539.172.13

2982. Radiative capture of protons by C^{13}. J. D. Seagrave. *Phys. Rev.*, **85**, 197–203 (*Jan.* 15, 1952).

The reaction $C^{13}(p,\gamma)N^{14}$ has been studied experimentally for proton bombarding energies between 0·4 and 2·7 MeV. Targets of carbon enriched in the isotope C^{13} were prepared, and thick and thin target excitation functions obtained. Five resonances were found, corresponding to excited states of N^{14} at 8·05, 8·62, 8·70, 9·18 and 9·49 MeV. The radiation spectrum from these levels was found to involve several branches of decay and transitions cascading through intermediate levels. A.

539.172.13

2983. Studies of nuclear collisions involving 8 MeV deuterons by the photographic method. IV. Angular distributions of the particles produced by the bombardment of helium and oxygen. E. J. Burge, H. B. Burrows, W. M. Gibson and J. Rotblat. *Proc. Roy. Soc. A*, **210**, 534–43 (*Jan.* 22, 1952).

An experimental technique described previously [Pt III, Abstr. 1216 (1952)] has been used to study the angular distributions of the products of nuclear processes occurring when He and O are bombarded by 8 MeV deuterons. Results on the elastic scattering of deuterons by He and O nuclei, and on the reactions $He^4(d,p)He^5$ and $O^{16}(d,p)O^{17}$, are presented and discussed. The results for the two groups of protons from the latter reaction allow it to be established that the ground state of O^{17} has spin $\frac{5}{2}$ or $\frac{3}{2}$ and even parity, while the 0·88 MeV excited state has spin $\frac{1}{2}$ and even parity. A.

539.172.13

2984. Studies of nuclear collisions involving 8 MeV deuterons by the photographic method. V. Angular distributions of charged particles from the bombardment of nitrogen and argon. W. M. Gibson and E. E. Thomas. *Proc. Roy. Soc. A*, **210**, 543–57 (*Jan.* 22, 1952).

Angular distributions have been measured for the elastically scattered deuterons, for two groups of α-particles from the reaction $N^{14}(d,\alpha)C^{12}$, for six groups of protons from the reaction $N^{14}(d,p)N^{15}$, and for three groups of protons from the reaction $A^{40}(d,p)A^{41}$. Some information about the spins and parities of the various energy states of the nuclei produced in the (d,p) reactions has been obtained from the results. A.

539.172.13

2985. Angular distribution of elastically scattered deuterons and disintegration protons from the bombardment of beryllium by 7·7 MeV deuterons. F. A. El-Bedewi. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 64–8 (*Jan.*, 1952).

The deuteron beam from the Liverpool 37 in cyclotron was used to bombard a thin Be foil in a vacuum chamber. The photographic plate method was employed in detecting the charged particles emitted from the reaction. The angular distribution of the elastically scattered deuterons shows a secondary maximum at 65°. Angular distributions of the two longest range proton groups are compared with the recent theories of the angular distributions of the (d,p) and (d,n) reactions. The results indicate that

both the ground state and first excited state of the residual nucleus Be^{10} have even parity and spin either 0, 1, 2 or 3. A.

539.172.13

2986. Nuclear reaction energies. D. M. Van Patter, A. Sperduto, P. M. Endt, W. W. Buechner and H. A. Enge. Letter in *Phys. Rev.*, **85**, 142–3 (*Jan.* 1, 1952).

These were measured for 14 (d,p) and (d,α) reactions involving Ne, Mg, Na, Al, Si, P isotopes using a magnetic spectrograph. The results show good internal consistency, link nuclear masses from Ne^{20} to P^{32} and predict correctly β disintegrations of Na^{24}, Mg^{27}, Al^{28}, Si^{31}. W. J. Swiatecki

539.172.13

2987. Neutrons from the disintegration of the separated isotopes of silicon by deuterons. C. E. Mandeville, C. P. Swann, S. D. Chatterjee and D. M. Van Patter. *Phys. Rev.*, **85**, 193–6 (*Jan.* 15, 1952).

The neutron spectra from deuterons on silicon have been studied by the method of recoil protons and photographic plates. Thick isotopic targets of the three separated isotopes of silicon were irradiated by deuterons of energy 1·4 MeV, supplied by the Bartol Van de Graaff statitron, observations being carried out at angles of zero and ninety degrees with the incident deuterons. Q-values, from which energy levels in the residual nuclei of phosphorus may be calculated, are tabulated. A.

539.172.13

2988. An investigation of alpha-particle groups from $Al^{27}(d,\alpha)Mg^{25}$. E. C. Toops, M. B. Sampson and F. E. Steigert. *Phys. Rev.*, **85**, 280–3 (*Jan.* 15, 1952).

The α-particle groups produced by the bombardment of Al by 10·8 MeV deuterons have been measured using nuclear emulsion plates for detection. Seven new levels in Mg^{25} were found at 6·98, 7·85, 8·62, 9·06, 9·75, 10·78 and 11·89 MeV. The previously known level at 4·01 MeV has been resolved into two levels at 3·96 and 4·12 MeV. A.

539.172.13

2989. The disintegration of lithium by deuteron bombardment. L. M. Baggett and S. J. Bame, Jr. *Phys. Rev.*, **85**, 434–6 (*Feb.* 1, 1952).

Thin target excitation curves for the $Li^7(d,n)$, $Li^6(d,n)$ and $Li^7(d,p)$ reactions are presented. The neutron data were taken at 90° to the deuteron beam using a BF_3-filled proportional counter in the long geometry. Resonances were observed in the $Li^6(d,n)$ reaction at 0·41 and at 2·12 MeV, in the $Li^7(d,n)$ reaction at 0·68, 0·98 and 2·1 MeV, and in $Li^7(d,p)$ reaction at 0·75, 1·00 and 1·4 MeV. These resonances correspond to excited states in Be^8 at 22·58 and 23·86 MeV and in Be^9 at 17·22, 17·45, 17·8 and 18·3 MeV. The cross-section of the resonances observed in the $Li^6(d,n)$ reactions were 9 and 41 millibarns/steradian, those for the $Li^7(d,n)$ reaction were 39, 43 and 58 millibarns/steradian, and those for the $Li^7(d,p)$ reaction were 0·230, 0·235 and 0·255 barn. A.

539.172.13

2990. Absolute excitation function of the $Be^9(d,t)$ reaction. R. L. Wolfgang and W. F. Libby. *Phys. Rev.*, **85**, 437–40 (*Feb.* 1, 1952).

The gas counting technique used earlier for the absolute assay of natural waters for T has been applied to the reactions producing T by the deuteron bombardment of Be. Absolute yield measurements for both thick and thin Be targets with deuteron energies ranging from 350 keV to 7·7 MeV have shown that the reaction cross-section rises rapidly at about 1·5 MeV to a flat plateau at $0{\cdot}23 \pm 0{\cdot}01$ barn, extending up to 7·7 MeV. From these results the T production appears to be about as prolific as the neutron production. In general one feels that the large magnitude of the (d,t) cross-section must be associated with the low binding energy of the extra neutron in Be^9. A.

539.172.13

2991. Measurement of the cross section for the reaction $T + T \rightarrow He^4 + 2n + 11{\cdot}4$ MeV. H. M. Agnew, W. T. Leland, H. V. Argo, R. W. Crews, A. H. Hemmendinger, W. E. Scott and R. F. Taschek. Letter in *Phys. Rev.*, **84**, 862–3 (*Nov.* 15, 1951).

The cross-section was measured for energies of the incident tritons between 0·04 and 2·22 MeV. The angular distribution of the neutrons emitted is also shown for a typical run. A. O. Stanesby

539.172.13

2992. Protons and deuterons from $Li^6 + T$ reactions. T. P. Pepper, K. W. Allen, E. Almqvist and J. T. Dewan. Letter in *Phys. Rev.*, **85**, 155–6 (*Jan.* 1, 1952).

These were studied in the presence of α-particle background by combined use of magnetic selection and a scintillation detector. J. J. Wilkins

539.172.3

2993. Cross section for the reaction $Cu^{65}(\gamma,\alpha)Co^{61}$. R. N. H. Haslam, L. A. Smith and J. G. V. Taylor. Letter in *Phys. Rev.*, **84**, 840 (*Nov.* 15, 1951).

A previously reported [Abstr. 5761 (1951)] method was used. A maximum cross-section of 1·5 mb at 22 MeV was found. Ta strips were irradiated as monitors. F. R. Holt

539.172.3

2994. Gamma-neutron cross sections for N^{14} and O^{16}. H. E. Johns, R. J. Horsley, R. N. H. Haslam and A. Quinton. Letter in *Phys. Rev.*, **84**, 856–7 (*Nov.* 15, 1951).

Cross-sections for the reactions $O^{16}(\gamma,n)O^{15}$ and $N^{14}(\gamma,n)N^{13}$ were obtained for incident γ-rays of 10–26 MeV. The O^{16} cross-section shows a max. (11·4 millibarns) at 24·2 MeV, the N^{14} cross-section a small max. ($\sim 0{\cdot}3$ mb) at 13 MeV, and the main max. (2·84 mb) at 24·2 MeV. A. O. Stanesby

539.172.3

2995. Phototripartition of carbon 12 by the 17·6-MeV γ-rays from lithium bombarded by protons. R. Chastel. *C.R. Acad. Sci.* [*Paris*] **233**, 1440–2 (*Dec.* 3, 1951); Erratum, *ibid.*, **234**, 572 (*Jan.* 28, 1952) *In French.*

From experimental data the author claims to show that the photodisintegration $C^{12}(\gamma,3\alpha)$ probably

occurs in a single stage, involving no intermediate Be^{8*} nucleus. J. J. WILKINS

539.172.3

2996. Angular distribution in the high energy deuteron photoeffect. N. AUSTERN. *Phys. Rev.*, **85**, 283–90 (*Jan.* 15, 1952).

Consideration is given to the possible use of the electric dipole isotropic part of the deuteron photodisintegration cross-section as an indicator of weak odd state non-central forces. This cross-section is not very sensitive to weak tensor forces of the usual type, but is strikingly affected by a singular spin-orbit coupling. While for the usual tensor forces the ratio, a/b, of the isotropic to the $\sin^2\theta$ term in the cross-section varies slowly over a broad energy range, it rises rapidly with energy if the non-central force is strongly singular. Calculation is done in first Born approximation. A detailed estimate of the magnetic isotropic cross-section is included, for this is an unexpectedly large "background" to the electric term which is of interest. A.

539.172.3

2997. Energetic protons from nuclei exposed to 300-MeV bremsstrahlung. J. C. KECK. *Phys. Rev.*, **85**, 410–16 (*Feb.* 1, 1952).

The protons ejected from various nuclei by the photon beam from the 300 MeV Cornell synchrotron have been studied with a scintillation counter telescope capable of distinguishing particles of different mass. The energy spectrum of protons from C and Cd is roughly proportional to $1/E^2$ from 70 to 130 MeV and to $1/E^6$ from 130 to 240 MeV. The angular distribution of protons from C has a forward asymmetry which increased with proton energy. The yield per nucleus of 130 MeV protons from Be, C, Al, Cu, Cd and Pb is proportional to Z. The excitation function for 105 MeV protons exhibits a steep rise in the neighbourhood of a synchrotron energy of 200 MeV. The experimental results indicate the majority of the protons to be of photoelectric rather than mesonic origin. There is some evidence that the recoil particle involved in the production process carries off about half the primary photon energy, which suggests that it may be a neutron. A.

539.172.4

2998. On the determination of the effective cross-section of uranium for thermal neutrons. G. GUÉBEN. *Ann. Soc. Sci. Brux.* (*Sér.* 1) **65**, 125–8 (*Dec.*, 1951) *In French.*

Using the author's method of Abstr. 3795 (1951) this was found to be $5{\cdot}5 \pm 1$ barns. W. J. SWIATECKI

539.172.4

2999. Quadrupole radiation in *n*D capture. N. AUSTERN. Letter in *Phys. Rev.*, **85**, 147 (*Jan.* 1, 1952).

An improved estimate [see Abstr. 8982 (1951)] shows this to be negligible ($\sim 10^{-5}$ of the magnetic dipole cross-section). W. J. SWIATECKI

539.172.4

3000. Nuclear structure in fission. L. E. GLENDENIN, E. P. STEINBERG, M. G. INGHRAM AND D. C. HESS. Letter in *Phys. Rev.*, **84**, 860–1 (*Nov.* 15, 1951).

Mass spectrometer studies of U^{235} fission products have indicated that the yield of Mo isotopes in the mass region 98–100 is abnormally high. This is shown to correspond to a similar abnormality at mass numbers 133–137, assuming 2·5 neutrons per fission. It is suggested that the high Mo yield is due to a preference for 40-proton configuration.

L. R. SHEPHERD

539.172.4

3001. Slow neutron fission of Am^{242}, Am^{242m}, and Am^{243}. K. STREET, JR, A. GHIORSO AND S. G. THOMPSON. Letter in *Phys. Rev.*, **85**, 135–6 (*Jan.* 1, 1952).

Cross-sections for this are deduced to be $\sim 6\,000$, $\sim 2\,000$ and $\lesssim 40$ barns respectively from the isotopic composition of Am^{241} samples irradiated with neutrons and from fission counter experiments.

W. J. SWIATECKI

539.172.4

3002. Some comments on the mechanism of fission. G. T. SEABORG. Letter in *Phys. Rev.*, **85**, 157–8 (*Jan.* 1, 1952).

The plot of the log of the spontaneous fission half-lives against Z^2/A for 14 nuclides is roughly linear for even-even nuclei, the even-odd ones lying higher. The larger radius of the latter is invoked to account for their stability. W. J. SWIATECKI

ATOM AND MOLECULAR BEAMS. MESONS NEUTRONS 539.18

539.18

3003. Proton-antiproton annihilation with emission of neutral and charged vectorial mesons. R. S. LIOTTA. *Nuovo Cim.*, **8**, 857–73 (*Nov.*, 1951) *In Italian.*

The probability of proton-antiproton annihilation into two charged or neutral vectorial mesons has been studied. The cross-section for meson production behaves as $1/(\gamma - 1)$ for $\gamma \to 1$ (γ being the energy of the negative proton divided by its rest energy in the system where the positive proton is at rest), while for $\gamma \to \infty$ the longitudinal part becomes infinite and the transversal part infinitesimal. For an energy of the negative proton of 2 000 MeV the cross-section is $\simeq 10^{-28}$ cm^2 for emission of neutral mesons and $\simeq 10^{-26}$ cm^2 for charged mesons. A.

539.18

3004. On the decay of μ-mesons. R. L. SETTI AND G. TOMASINI. *Nuovo Cim.*, **8**, 993–1005 (*Dec.*, 1951).

From multiple scattering measurements in nuclear emulsions an energy spectrum of the decay particles of the μ-mesons is obtained. The results are analysed with particular regard to the high energy region of the spectrum and then compared with the results reported by other authors on the same subject. From the comparison with magnetic deflection measurements in the Wilson chamber it is possible to estimate the reliability of the results obtained from scattering measurements and to obtain informations on the validity of the scattering theory of Williams–Molière, for the energy interval relative to the spectrum considered. Some examples are described of annihilation and bremsstrahlung processes which

support the hypothesis that the μ-decay particles are of mass very close to that of the electron. A.

539.18

3005. Decay of the π-meson. M. RUDERMAN. Letter in *Phys. Rev.*, **85**, 157 (*Jan.* 1, 1952).

The decay probabilities for $\pi \rightarrow e, \nu$ or μ, ν with or without γ-emission and for various couplings between the particles. W. J. SWIATECKI

539.18 : 539.172.13

3006. Production cross sections for π^+- and π^--mesons by 340-MeV protons on carbon and lead at 90° to the beam. C. RICHMAN, M. WEISSBLUTH AND H. A. WILCOX. *Phys. Rev.*, **85**, 161–5 (*Jan.* 15, 1952).

Carbon and lead targets were bombarded by 340 MeV protons produced by the Berkeley 184 in synchro-cyclotron. The spectrum of π^+- and π^+-mesons produced at $90° \pm 12°$ to the beam was measured by the use of nuclear emulsions embedded in absorbers. The total cross-section for the production of π^+-mesons from carbon at this angle is $(2{\cdot}3 \pm 0{\cdot}5) \times 10^{-28}$ cm^2 ster^{-1}, and the π^+ to π^- ratio is $5{\cdot}1 \pm 1{\cdot}0$. For lead the cross-section for π^+-mesons at this angle is $(7 \pm 2{\cdot}1) \times 10^{-28}$ cm^2 ster^{-1} and the π^+ to π^- ratio is $1{\cdot}5 \pm 0{\cdot}4$. A.

539.18 : 539.172.13

3007. π-Meson production by protons on nuclei. E. M. HENLEY. *Phys. Rev.*, **85**, 204–15 (*Jan.* 15, 1952).

The meson production cross-section for protons incident on nuclei is formulated in terms of two-particle transition rates and the struck nucleon momentum distribution in the nucleus. Three different momentum densities are assumed. They are a modified Chew–Goldberger, a Gaussian and a Fermi distribution. With these, it is attempted to fit the experimental π^+ and π^- meson spectra obtained by bombarding C^{12} with 345 MeV protons. The effect of the exclusion principle is estimated on the basis of a single particle model for the nucleus. Meson reabsorption and scattering, after production, are also taken into account, but only roughly. The calculations show that the Gaussian distribution approximates nuclear conditions best, and that the fundamental proton-neutron and proton-proton production transitions matrices are most probably not equal. A.

539.18 : 539.172.13

3008. The yield of neutral mesons from proton bombardment of light nuclei. R. W. HALES, R. H. HILDEBRAND, N. KNABLE AND B. J. MOYER. Letter in *Phys. Rev.*, **85**, 373–4 (*Jan.* 15, 1952).

Gamma-ray (π^0-decay) yields from H^1, H^2, Be^9, B^{10}, B^{11}, C^{12} and O^{16} have been determined. The results suggest that the π^0 yield from p–n collisions is much greater than from p–p collisions, in accordance with pseudoscalar meson selection rules. J. J. WILKINS

539.185

3009. Time-dependent neutron sources in multiplying media. I. S. GALLONE, L. ORSONI AND C. SALVETTI. *Nuovo Cim.*, **8**, 960–9 (*Dec.*, 1951) *In Italian.*

Subcritical multiplying media containing non-periodical time-dependent neutron sources are studied in the case of modulated and moving sources. Some simple cases, such as the instantaneous injection with a point source, the switching of a source of constant intensity and the moving source are considered. A short discussion on the correction for non-vanishing mean free path of liberated neutrons and finite slowing-down times follows. The transient behaviour depends upon the characteristic parameters of the multiplying medium, so that such methods may be of some use for studying subcritical pile elements. A.

539.185

3010. Absence of spontaneous emission of neutrons from samarium. S. D. CHATTERJEE AND R. N. OLCOTT. Letter in *Phys. Rev.*, **85**, 147–8 (*Jan.* 1, 1952).

This was demonstrated [in contradiction with Yagoda and Kaplan, Abstr. 527 (1950)] using a large quantity of Sm in the form of sticks embedded together with enriched-BF_3 counters in a large paraffin cylinder. Possible explanations of the discrepancy are discussed. W. J. SWIATECKI

539.185

3011. Analysis of high-energy neutron production. F. MANDL AND T. H. R. SKYRME. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 101–9 (*Feb.*, 1952).

The energy spectra of neutrons scattered in the forward direction when different target nuclei are bombarded with high-energy protons are calculated and compared with recent measurements. The calculation is subdivided into 3 stages: (i) as a crude analogue to the nuclear scattering, the scattering of a single neutron in a square well is calculated using Born approximation; (ii) single scattering processes are estimated classically using the results of (i) to allow for the momentum distribution of the target neutron, and allowing for the attenuation of incident and scattered beams; (iii) multiple scattering is estimated similarly. Several simplifying assumptions have to be made and double collisions only are estimated. The calculated differential cross-sections are in fairly good agreement with experiment, but the calculated energy spectrum falls off too quickly. The effect of neglecting certain processes, such as triple collisions, is discussed, as well as the applicability of the nuclear model used. A.

539.185 : 537.534.74

3012. Polarization effects in n–p scattering. D. R. SWANSON. Letter in *Phys. Rev.*, **84**, 1068–9 (*Dec.* 1, 1951).

The expected azimuthal asymmetry in a double scattering of high energy n by p is calculated, using the "half-exchange" n–p interaction of Christian and Hart [Abstr. 4377 (1950)]. The results also apply if the first scatter is p–n; this facilitates comparison with experiment (see abstract following). F. R. HOLT

539.185 : 537.534.74

3013. Detection of the azimuthal polarization of the n–p interaction at 150 MeV. L. F. WOUTERS. Letter in *Phys. Rev.*, **84**, 1069–70 (*Dec.* 1, 1951).

The first (p, n) scattering uses a LiD target block inside a cyclotron tank; the second (n, p) scattering uses paraffin. Results agree reasonably with Swanson's theory (preceding abstract). F. R. HOLT

539.185 : 537.534.74 : 530.145

3014. The analysis of high energy neutron-proton and proton-proton scattering data. R. S. CHRISTIAN. *Rep. Phys. Soc. Progr. Phys.*, **15**, 68–100 (1952).

The phenomenological description of the nucleon-nucleon interaction in terms of a static potential is reviewed. The scattering cross-sections at various energies from 28 to 340 MeV are calculated from various assumed potential models and compared with the experimental results. Fair agreement may be obtained for *n–p* scattering with a potential model having no interaction in the odd parity states and a "long-tailed" radial dependence. The predicted total cross-sections are some 20% too high, suggesting either that the potential may become repulsive at short distances or that the potential description breaks down in *S* states at high energies. Proton-proton scattering results require a large fraction of the total scattering at high energies to be in the odd parity states. These odd parity forces are definitely of a non-central character. An extremely strong interaction at short distances is required, which may take the form of a repulsive core in the singlet state or may be of a tensor nature in the triplet states. A charge-independent nuclear force is not indicated; however, the possibility of finding such a formulation has not been eliminated. Possible models are suggested. A summary of the knowledge of the interaction in all the various independent *n–p* and *p–p* states is reviewed. (Bibl. 81 items.) A.

539.185 : 538.221

3015. Slow neutron scattering by ferromagnetic crystals. R. G. MOORHOUSE. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1097–1107 (*Dec.*, 1951).

Consideration is made of the predictions of the Bloch spin wave model within its region of approximate validity, for the magnetic scattering of very slow neutrons by a ferromagnetic. It is found that observable peaks of intensity in the angular distribution of scattered neutrons occur due to spin wave absorption. Neutrons are also scattered with phonon absorption and by an analogous calculation it can be shown that similar peaks occur due to this vibrational scattering. A possible method is suggested of differentiating between the two kinds of scattering in order to provide a check of the Bloch model. A.

STRUCTURE OF SOLIDS 539.2

539.215.4 : 537.531 : 535.43

3016. The size of latex particles by X-ray scattering. B. R. LEONARD, J. W. ANDEREGG, P. KAESBERG AND W. W. BEEMAN. Letter in *J. Appl. Phys.*, **23**, 152 (*Jan.*, 1952).

A diameter of 2 590 Å has been accepted by electron microscopists for the polystyrene Dow latex 580G, lot 3584 used as a calibration standard. Small-angle X-ray scattering from dry samples and from methyl alcohol suspensions gave a mean value for the diameter of 2 731 Å. The weighted average deviation from the mean was 34 Å and the statistical accuracy of the mean is approximately ± 3 Å. J. IBALL

539.217

3017. Diffusion in indium near the melting point. R. E. ECKERT AND H. G. DRICKAMER. *J. Chem. Phys.*, **20**, 13–17 (*Jan.*, 1952).

Diffusion coefficients for the systems Tl^{204}–In and In^{114}–In have been measured in the solid state and in the neighbourhood of the melting point. The measurements were made in both polycrystalline masses and in single crystals. For the polycrystalline samples a rapid, but not discontinuous, rise in the diffusion coefficient occurred about 0·5°C below the melting-point. For the Tl^{204}–In system in a single crystal the rise in *D* occurs just below the melting-point. This indicates grain boundary melting in the polycrystalline sample. For the In^{114}–In diffusion in a single crystal the rapid rise still occurred well below the melting-point, indicating that increasing lattice disorder also contributes to the increase in *D*. A.

539.217

3018. On the calculation of integral diffusion coefficients from free diffusion experiments. G. KRAUS. Letter in *J. Chem. Phys.*, **20**, 200 (*Jan.*, 1952).

The standard solution of the diffusion equation $\partial c/\partial t = (\partial/\partial x)(D\partial c/\partial x)$ for diffusion between two infinite volumes across an initial sharp boundary, or for diffusion from a reservoir of constant concentration into a semi-infinite volume, gives the diffusion coefficient D as a function of concentration c: $D(c) = (1/2)(\partial\xi/\partial c)\int_{c_1}^{c} \xi dc$, where $\xi = x/t^{\frac{1}{2}}$ and c_1 and c_2 are the initial concentrations on either side of the boundary. A convenient mean value of D, defined as $\bar{D} = [1/(c_2 - c_1)]\int_{c_1}^{c_2} D(c)dc$, may be obtained directly from the experimental measurements of c as a function of x and t by the equation

$$\bar{D} = (1/2)[1/(c_2 - c_1)]\int_{c_1}^{c_2} \xi^2 dc$$

A. D. LE CLAIRE

539.217.5

3019. The transmission of hydrogen through metals. H. B. WAHLIN. Letter in *J. Appl. Phys.*, **22**, 1503 (*Dec.*, 1951).

Preliminary experiments reported. Hydrogen is found to pass through a Pd tube acting as cathode in a sulphuric acid bath. The quantity transmitted (as much as 1·5 cm³ per cm² per min) increases rapidly with temperature and a pressure of 700 lb/in² was built up inside the tube. Other metals exhibit similar effects. Applications are suggested. R. H. DAVIES

539.219 : 534.24

Ultrasonic detection of defects. *See Abstr.* 2539–40

539.231

3020. The structure of sputtered silver films. C. E. ELLS AND G. D. SCOTT. *J. Appl. Phys.*, **23**, 31–4 (*Jan.*, 1952).

The electron microscope has been used to study the structure of sputtered Ag films. When compared with evaporated Ag films which are prepared at the same rate, the sputtered films are observed to have a more continuous structure. When compared with evaporated Ag films which are produced at much

faster rates, the sputtered films exhibit a crossover phenomenon in which the thinner films are the more continuous and the thicker films less continuous than evaporated films of the same thickness. These properties are in agreement with resistivity measurements. A possible explanation for the results is proposed. A.

539.234

3021. Electron diffraction evidence for the existence of microstress in evaporated metal films. E. K. HALTEMAN. *J. Appl. Phys.*, **23**, 150–1 (*Jan.*, 1952).

The line broadening in electron diffraction powder patterns from evaporated nickel films has been investigated. The pure diffraction broadening was found to vary with the Bragg angle in agreement with a microstress theory of broadening rather than with a particle size mechanism. The Fourier transform of the pure diffraction broadening has been determined and also found to be in agreement with a microstress mechanism. A.

539.234

3022. Absolute determination of condensation factors of molecular jets of antimony on a surface. M. DEVIENNE. *C.R. Acad. Sci.* [*Paris*] **234**, 80–1 (*Jan.* 2, 1952) *In French.*

On evaporating radioactive Sb on to a Cu base, the condensation factor was 74% when the layer was 40 Å thick, and about 55% when the layer was 14 Å thick. These factors were determined by comparing the radioactivity of the material of the layer with that of the total amount of material. N. CORCORAN

539.24/.27 : 539.373

3023. On the sub-structure of metallic crystals. H. NISHIMURA, Y. MURAKAMI AND J. TAKAMURA. *Tech. Rep. Engng Res. Inst. Kyoto Univ.*, **1**, 19–27 (*No.* 2, 1951).

Optical, electron microscope and X-ray investigations of the grain boundary, sub-boundary and mosaic boundary structure of Al, Al alloys and Cu. The more pure the metal the less extensive is the distorted grain boundary region and the more distinct the grain boundary. Sub-boundaries are of two types, one relatively stable against heat treatment on account of the segregation in them of impurities, and the other showing a tendency to disappear on prolonged annealing and due only to the irregular arrangements of atoms between the slightly disoriented "sub-grains." Mosaic boundaries, in Al single crystals (99·95%), define mosaic blocks of $\sim 10^{-4}$ cm which on prolonged annealing at 650°C increase in size to $\sim 10^{-3}$ cm. On plastic deformation fragmentation to a size $\sim 10^{-6}$ cm occurs which is severe near slip bands but less pronounced in the interslip region. This fragmentation is considered important as impeding the movement of dislocation. 24 photographs. A. D. LE CLAIRE

539.27

3024. Electron diffraction study on the ordered alloy Au_3Cu. S. OGAWA AND D. WATANABE. Letter in *J. Appl. Phys.*, **22**, 1502 (*Dec.*, 1951).

Domains of order persist at temperatures up to 500°C. The domain size decreases steadily from 50 Å at 200°C to 11 Å at 500°C. R. S. PEASE

539.27

3025. On the use of chlorinated rubber for object-supporting films in electron microscopy. F. DAVOINE AND E. PERNOUX. *C.R. Acad. Sci.* [*Paris*] **233**, 1590–1 (*Dec.* 19, 1951) *In French.*

Preparation methods are given. The films are similar in appearance to collodion films, but are resistant to alcohol and concentrated acids. R. S. PEASE

ELASTICITY . STRENGTH . RHEOLOGY 539.3/.8

539.31

3026. Experiments on the mechanics of rubber. I. Eversion of a tube. A. N. GENT AND R. S. RIVLIN. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 118–21 (*Feb.*, 1952).

Measurements are made of the changes which take place in the dimensions of rubber tubes when they are turned inside out. These are compared with the values predicted from the theory of large elastic deformations of incompressible isotropic materials. A.

539.31 : 530.162

3027. Statistical theory of rubber-like elasticity. IV. Two dimensional stretching. A. ISIHARA, N. HASHITSUME AND M. TATIBANA. *J. Chem. Phys.*, **19**, 1508–12 (*Dec.*, 1951).

For Pt III, see Abstr. 2036 (1950). The failure, revealed by the experiment of Treloar, of statistical theories of the rubber-like elasticity is removed. It comes from the neglect of the non-Gaussian character and of the non-linear connectivity of the network structure. The theoretical formula derived here includes the semi-empirical formula given by Treloar. A.

539.312

3028. A contribution on the velocity of longitudinal elastic vibrations in cylindrical rods, and on the relationship between Young's modulus and temperature for aluminium. E. G. STANFORD. *Nuovo Cim.*, **7**, 332–40 (*Suppl. No.* 2, 1950).

Taking V_1 as the velocity corresponding to Young's modulus (E) and the density of the material (ρ), where $V_1 = \sqrt{E/\rho}$ and V is the velocity determined by longitudinal resonance experiments on specimens of the material of length L and radius a ($V = 2LN/\beta$, where N is the frequency of vibration and β is an integer corresponding to the particular mode of vibration), when V/V_1 is plotted versus $\beta a/L$ the resulting line falls steadily from unity at $\beta a/L = 0$ to a constant value of about 0·6 at values of $\beta a/L$ exceeding about 1·4. When specimens of pure Al were tested within the temperature range 20–650°C, Young's modulus fell steadily with increase of temperature and a sharp dip occurred in the curve with a specimen which had previously been strained by about ½%. When the specimen was cooled and reheated the dip did not occur, indicating a transition from the unrelaxed to the relaxed modulus. In both cases, the corresponding damping curves showed maxima at about 500°C. A. C. WHIFFIN

539.312 : 534.321.9

3029. Examination of metallic alloys by ultrasonics. I. Barducci. *Nuovo Cim.*, **7**, 347–58 (*Suppl. No.* 2, 1950) *In Italian.*

A summary of the present state of knowledge regarding the effects of alloying elements on the damping and internal friction of metals subjected to longitudinal and flexural vibration. Pure Fe, containing only 0·005% C, shows a considerable maximum internal friction at 470°c, which vanishes when the C content is raised to 0·07% C. Similarly, when Cu is tested at various temperatures, increase of the Bi content from 0·0026% to 0·010% has a marked effect on the internal friction at about 290°c. Studies are also made of the internal friction and the modulus of elasticity of Cu–Zn alloys, and of the effect of change of tempering temperature of Cr-steel. It is concluded that the ultrasonic technique is very useful in this field. A. C. WHIFFIN

539.312 : 539.4.016

3030. Internal friction in iron and steel. J. D. Fast and L. J. Dijkstra. *Philips Tech. Rev.*, **13**, 172–9 (*Dec.*, 1951).

Damping experiments, at different temperatures, with a torsional wire pendulum made of iron or steel containing a little C or N in solution (with or without the admixture of Mn) throw some light upon the extent to which the dissolved atoms precipitate after quenching of the metal. It is shown how the internal friction, resulting from the solute atoms jumping from one interstice in the crystal lattice to another, causes the amplitude of the torsional oscillations to decay exponentially. At a certain frequency the degree of damping depends upon the rate of diffusion of the atoms and thus upon the temperature, the logarithmic decrement as a function of the temperature showing a maximum at a very definite temperature. The height of this maximum is directly proportional to the amount of dissolved atoms and thus decreases with increasing precipitation. In conformity with the conclusions drawn from hardness measurements described in the preceding abstract, Mn appears to have no influence upon the precipitation of C in C-containing Fe after quenching, whilst the precipitation of N in N-containing Fe is greatly retarded by Mn, so much so that even after 66 hours' heating at 200°c (after quenching) only about one-third of the N is precipitated in the form of a (metastable) nitride. These results throw light upon the atomic processes responsible for this behaviour and make possible a new explanation of "magnetic ageing." A.

539.32

3031. Variation of elastic moduli with temperature for various steels and pure metals. G. T. Harris and M. T. Watkins. "*Symposium on high-temperature steels and alloys for gas-turbines.*" *Special Report* (*No.* 43) *Iron and Steel Institute* (1951) 185–8.

Determinations of Young's modulus for several gas-turbine materials and pure Al and Ni, at temperatures up to 800°c, have been made by static and dynamic methods. In general the values determined by the two methods agree within 1%. The variation with temperature of the modulus of rigidity and Poisson's ratio has been determined for two steels. A.

539.32

3032. On the calculation of characteristic temperatures from the elastic constants. M. Blackman. Letter in *Phil. Mag.*, **42**, 1441–2 (*Dec.*, 1951).

A semi-theoretical formula for θ_D, when C_{11}–C_{12} is relatively small, is quoted. It is derived from consideration of surfaces of constant frequency and a remaining constant is chosen to give a close fit to θ_D for Li calculated by standard methods. θ_D values are calculated for Ag–Au alloys. J. E. CAFFYN

539.32

3033. The thermal dependence of the elastic moduli of polycrystalline graphite. F. E. Faris, L. Green, Jr and C. A. Smith. *J. Appl. Phys.*, **23**, 89–95 (*Jan.*, 1952).

Young's modulus and the shear modulus of grade SA-25 moulded graphite and grade AUF extruded graphite were measured as functions of temperature in the range from 25°c to 2 000°c. In the case of the extruded material, variations of the two moduli with position and direction relative to the axis of extrusion were also investigated. The moduli were found to increase with temperature, a behaviour in contrast with that exhibited by most materials. Maxima in the low frequency shear modulus values and increases in the internal friction of both graphites observed in the range from 1 550–1 750°c may possibly be interpreted in terms of grain boundary relaxation. The bulk modulus and Poisson's ratio at room temperature were calculated from the data for the nominally isotropic SA-25 graphite to be 6×10^{10} dynes/cm² and 0·27, respectively. A.

539.32 : 537.228.2

3034. Determination of the elastic constants of piezoelectric and ferroelectric crystals. F. Jona. *Nuovo Cim.*, **7**, 229–30 (*Suppl. No.* 2, 1950). *In Italian.*

The differences are emphasized between the moduli of elasticity of crystals when the electric field generated by strain is permitted or cancelled. A brief outline is given of a series of experiments which have been made and will be described elsewhere. A. C. WHIFFIN

539.32 : 541.64 : 534.22

Application of ultrasonics to the measurement of the elasticity of high polymers. *See Abstr.* 2502

539.32 : 548.0

3035. Determination of the elastic constants of ice. F. Jona and P. Scherrer. *Nuovo Cim.*, **8**, 981–93 (*Dec.*, 1951) *In Italian.*

The elastic behaviour of single crystals of ice was determined by observing the diffraction of light on supersonic waves (method of Schaefer and Bergmann). Two methods for the growing of single crystals of ice up to 9 cm diameter and 6 cm in height are described. All of the five elastic constants c_{ik} of these crystals are determined for a temperature of −16°c. A comparison of the experimental results with the values calculated theoretically by Penny shows satisfactory agreement. A.

539.371

3036. General theory of small elastic deformations superposed on finite elastic deformations. A. E. Green, R. S. Rivlin and R. T. Shield. *Proc. Roy. Soc. A*, **211**, 128–54 (*Feb.* 7, 1952).

Using tensor notations a general theory is developed

for small elastic deformations, of either a compressible or incompressible isotropic elastic body, superposed on a known finite deformation, without assuming special forms for the strain-energy function. The theory is specialized to the case when the finite deformation is pure homogeneous. When two of the principal extension ratios are equal the changes in displacement and stress due to the small superposed deformation are expressed in terms of two potential functions in a manner which is analogous to that used in the infinitesimal deformation of hexagonally aeolotropic materials. The potential functions are used to solve the problem of the infinitesimally small indentation, by a spherical punch, of the plane surface of a semi-infinite body of incompressible isotropic elastic material which is first subjected to a finite pure homogeneous deformation symmetrical about the normal to the force-free plane surface. The general theory is also applied to the infinitesimal deformation of a thin sheet of incompressible isotropic elastic material which is first subjected to a finite pure homogeneous deformation by forces in its plane. A differential equation is obtained for the small deflection of the sheet due to small forces acting normally to its face. This equation is solved completely in the case of a clamped circular sheet subjected to a pure homogeneous deformation having equal extension ratios in the plane of the sheet, the small bending force being uniformly distributed over a face of the sheet. Finally, equations are obtained for the homogeneously deformed sheet subjected to infinitesimal generalized plane stress, and a method of solution by complex variable technique is indicated. A.

539.374 : 548.0

3037. Deformation of body-centered cubic metals. E. A. CALNAN AND C. J. B. CLEWS. Letter in *J. Appl. Phys.*, **22**, 1508 (*Dec.*, 1951).

Previous work [Abstr. 1373 and 9030 (1951)] has been repeated with new ratios of critical resolved shear stresses in silicon ferrite, those previously quoted being in error. J. E. CAFFYN

539.374 : 548.0

3038. On the ratio of the critical shear stresses. A. J. OPINSKY AND R. SMOLUCHOWSKI. Letter in *J. Appl. Phys.*, **22**, 1508 (*Dec.*, 1951).

See preceding abstract.

539.382

3039. Investigation of stress-strain relations of metal wires by electrical resistance changes. I. VIGNESS. *J. Appl. Phys.*, **23**, 43–7 (*Jan.*, 1952).

A method is described by which the stress-strain curve of a wire tensile specimen can be derived from measurements of its changes of electrical resistance as a function of strain. The method can be applied only to a selected group of metals that have experimentally been shown to be suitable. A material is suitable when its resistance changes per unit of elastic and per unit of plastic strain are each constant and different from each other. The method assumes uniform strain throughout the length of the specimen, which limits conditions studied to those prior to necking. Examples are shown illustrating the linear resistance-strain relations and the applications of the method for several suitable materials. The resistance-strain characteristics of several materials that are not suitable are given, together with a statement of some mechanisms responsible. A.

539.4.015 : 541.64

3040. Effect of orientation on the mechanical properties of polystyrene. R. G. CHEATHAM AND A. G. H. DIETZ. *Trans Amer. Soc. Mech. Engrs*, **74**, 31–40 (*Jan.*, 1952).

Extruded polystyrene rod was first annealed, and then stretched hot to elongations as high as 12 000%. Tests were made in tension, flexure and torsion at temperatures ranging from 0 to 80°C. Tests included creep and relaxation as well as tests at strain and load rates ranging as high as 1·0 in/in/min and 10 000 lb per min to determine the effect of orientation upon these mechanical properties. Tensile and flexural strengths increased two to threefold, depending upon rate and temperature; torsional strength decreased; and modulus of elasticity increased moderately. Fracture changed from a sharp break to a fibrous separation. Birefringence measurements revealed marked orientation of the material, but low-angle X-ray diffraction studies revealed no "crystalline" structure. A.

539.4.016

3041. Ageing phenomena in iron and steel after rapid cooling. J. D. FAST. *Philips Tech. Rev.*, **13**, 165–71 (*Dec.*, 1951).

This quench ageing is to be ascribed to the presence of certain constituents in the metal. The hardness of α-Fe containing small quantities of C, N or O separately has been determined after various heat treatments. Also the influence of Mn on the ageing of α-Fe with C or N has been studied. Mn appears to be capable of suppressing the quench ageing of Fe containing N but not that of Fe containing C. Considering the comparatively great affinity between Mn and N, an explanation is sought by assuming that in the crystal lattice the N atoms will preferably occur in the vicinity of Mn atoms, where they are bound much more strongly than when surrounded exclusively by Fe atoms, so that the formation of Fe nitride, thus the precipitation, takes place at a perceptible rate only at high temperatures. A.

539.42

3042. Glass cracking caused by high explosives. E. M. PUGH, R. v. HEINE-GELDERN, S. FONER AND E. C. MUTSCHLER. *J. Appl. Phys.*, **23**, 48–53 (*Jan.*, 1952).

High-speed photographs have been obtained of the fracture of glass produced by the detonation of a high explosive charge. Using photoelastic methods, the shock waves set up in the glass can also be photographed. In addition to providing a high-intensity loading method, the explosive also serves as a convenient time base for determination of the rates of propagation of shock waves and cracking. The results presented in this paper extend those obtained by other investigators who used low-energy impacts to produce fracture. A.

539.434

3043. A constant stress device adjustable for specimen length. A. J. KENNEDY. *J. Sci. Instrum.*, **29**, 40–4 (*Feb.*, 1952).

It is clearly advantageous to be able to utilize a

single constant stress device with specimens of different length. It is shown here that, by the addition of a secondary profile, the Andrade–Chalmers profile device can be made applicable to specimens ranging in length from 0·5 to 1·5 times the length for which the main profile is designed. Very high accuracies can be achieved if desired, but by making one adjustment only, namely by changing the value of the secondary load, constancy can be maintained to about 0·03% for 1% variation in initial length and up to 0·4% for a 50% variation in initial length. It is shown how the systems in question may be combined so as to increase the extensions within which this constancy is maintained. A.

539.62

3044. The friction and lubrication of solids. F. P. Bowden and D. Tabor. *Oxford, Clarendon Press* (1950) xii + 337 *pp.*

539.62

3045. Radioactive tracers for rapid measurement of cutting tool life. M. E. Merchant and E. J. Krabacher. Letter in *J. Appl. Phys.*, **22**, 1507–8 (*Dec.*, 1951).

Pile irradiation produced W^{185}, Ta^{182} and Co^{60} in the tool. Over 90% of the radioactive material worn from the tool remained attached to the chips produced in cutting, and counting the γ's from these gave a rapid and accurate measurement of tool wear, free from "cascading" effects. F. R. HOLT

539.62

3046. On the empirical law of adhesive wear. J. T. Burwell and C. D. Strang. *J. Appl. Phys.*, **23**, 18–28 (*Jan.*, 1952).

Careful measurements have been made of the wear of rubbing steel surfaces as a function of load, distance of travel and hardness under controlled conditions which eliminated the effect of all factors except adhesion. At normal pressures averaged over the apparent contact area which are less than one-third the hardness of the softer material the amount of wear was found to depend linearly on the distance of travel and on the load but was independent of the apparent area of contact. At average pressures greater than one-third of the hardness, the depth of wear varied linearly with the distance of travel, was independent of the apparent area of contact for a given average normal stress, but increased many fold for small increases in stress. These findings rationalize the familiar observations on the running-in of machine surfaces. The results are discussed in the light of the current adhesion theory of dry friction. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.115

3047. The heat of formation of nitric oxide and phosphorus trioxide. W. E. Koerner and F. Daniels. *J. Chem. Phys.*, **20**, 113–15 (*Jan.*, 1952).

The heat of formation of nitric oxide has been redetermined by burning samples of red phosphorus in nitric oxide and in an equimolecular mixture of nitrogen and oxygen. A varying fraction of the phosphorus consumed by reaction with nitric oxide was converted to phosphorus trioxide; the remainder being converted to the pentoxide. A value of 21·8 kcal per mole was obtained for the heat of formation of nitric oxide at 25°C. A value of −270 kcal per mole was chosen as the best value for the heat of formation of phosphorus trioxide at 25°C. A.

541.115

3048. The heat of dissociation of fluorine. R. N. Doescher. *J. Chem. Phys.*, **20**, 330–4 (*Feb.*, 1952).

Equilibrium pressure measurements of the dissociation of F_2 have been completed with the use of (1) a Ni vessel coated stepwise by heating in contact with F at temperatures up to 850°C and (2) a differentially applied manometer containing a fluorinated oil. This latter technique made it possible to carry out the measurements in the comparatively low temperature range 759° to 1115°K. The method consisted essentially in a direct comparison of the pressure variation with temperature of a quantity of F with that of a quantity of N. Twenty-four determinations of the equilibrium constant were made, and in a plot of $\ln K$ as a function of $1/T$, the points gave a straight line. The slope gave $\Delta H = 37{\cdot}7$ kcal/mole as the mean heat of dissociation in the temperature range of the experiments for the reaction $F_2(g) \rightarrow 2F(g)$. This ΔH value is in good agreement with values calculated from entropy quantities and values of $\ln K$ obtained from the line. A.

541.122.3 : 542.944

3049. Equilibria in the halogenation of some organic substances in aqueous solution. R. P. Bell and E. Gelles. *Proc. Roy. Soc. A*, **210**, 310–22 (*Jan.* 7, 1952).

Measurements of redox potential have been used to obtain equilibrium constants for the reaction of I and Br with aqueous solutions of ketones, esters and nitro-paraffins. Many of the iodination constants have an accuracy of a few %, but the bromination constants are not reliable to better than a power of ten. The iodination constants vary over 10 powers of ten, corresponding to considerable differences in the nature of the carbon-hydrogen and carbon-iodine bonds involved. The data are used to derive the heat of the reaction $RH + I \rightarrow RI + H$ in the gas phase, and the mean value obtained (46 kcal/mole) is consistent with earlier estimates. Approximate values are also derived for the equilibrium constants of the reaction $RI \rightarrow R^- + I^+$ in solution. For variations in R these are roughly parallel with the acid dissociation constants of the reaction $RH \rightarrow R^- + H^+$. A.

541.123.1 : 536.7

3050. Statistical thermodynamics of the transition region between two phases. II. One component system with a plane interface. T. L. HILL. *J. Chem. Phys.*, **20,** 141–4 (*Jan.*, 1952).

An approximate statistical theory is used to investigate the nature of the density transition curve in passing from a one-component liquid phase to the equilibrium vapour phase. This density curve is related thermodynamically to the surface tension, the surface energy, the location of the surface of tension, and to the dependence of surface tension on curvature. A.

541.123.5

3051. Existence of a limit to the spontaneous discharge of copper ions on metallic zinc. M. BANCIE-GRILLOT AND E. GRILLOT. *C.R. Acad. Sci.* [*Paris*] **233,** 1362–4 (*Nov.* 26, 1951) *In French.*

Detection of Cu^{++} ions to concentrations of 10^{-9} ions/g is achieved by using radioactive Cu^{64}. The method is applied to control of the preparation of copper-free zinc sulphide phosphors. The limit of purification is found to be 5×10^{-6} g Cu/g Zn in a boiling 10% solution of zinc sulphate. G. F. J. GARLICK

541.123.5 : 545.844

3052. Adsorption studies on clay minerals. I. Chromatography on clays. J. A. FAUCHER, JR, R. W. SOUTHWORTH AND H. C. THOMAS. *J. Chem. Phys.*, **20,** 157–60 (*Jan.*, 1952).

With the aid of chromatographic columns containing a clay mineral dispersed on asbestos, ion-exchange processes on this mineral have been studied. The results of isotopic exchanges show that the columns do not run under equilibrium conditions. These isotopic exchanges do make possible a correction procedure which serves to produce isotherms for cases of true ion-exchange. The details of the correction procedure are given together with some results for a cesium-sodium exchange on a montmorillonite from Chambers, Arizona. A.

541.124

3053. The kinetics of coordinate bond formation. D. GARVIN AND G. B. KISTIAKOWSKY. *J. Chem. Phys.*, **20,** 105–12 (*Jan.*, 1952).

A novel method has been developed for determining the rates of very fast gas-phase bimolecular reactions, which is based on interpretation of the temperature gradients in a flow system similar to that used for the study of the reactions of sodium vapour and alkyl halides. The kinetics of the reactions between boron trifluoride and tri-, di- and monomethylamine to form the corresponding co-ordinately bonded compounds have been studied. These reactions appear to have negligibly small activation energies, and their rates show a pressure dependence consistent with a mechanism: $y + z \rightleftharpoons yz^*$, $yz^* + m \rightarrow yz + m^*$, in which the long-lived intermediate yz^* must be stabilized by loss of energy in a collision. The random scatter of individual rate constants is about 20%. A.

541.124 : 539.155.2

3054. Isotope effect in the Cannizzaro reaction of carbon-14-labeled formaldehyde. A. M. DOWNES AND G. M. HARRIS. Letter in *J. Chem. Phys.*, **20,** 196–7 (*Jan.*, 1952).

This effect is investigated quantitatively by measurements of specific activities. A. J. TAYLOR

541.124

3055. The reaction of CH_3 and CD_3 radicals with hydrogen and deuterium. T. G. MAJURY AND E. W. R. STEACIE. Letter in *J. Chem. Phys.*, **20,** 197–8 (*Jan.*, 1952).

The activation energy and the steric factor of these reactions, yielding CX_4 (X = H or D), as well as the activation energy of the reverse reaction, are calculated on the basis of measurements of temperature coefficients and rate constants. A. J. TAYLOR

541.124

3056. The reaction of atomic hydrogen with ethane. M. R. BERLIE AND D. J. LEROY. Letter in *J. Chem. Phys.*, **20,** 200–1 (*Jan.*, 1952).

The rate constant of this reaction, which produces methane, is experimentally found by the method of J. R. Dingle and D. J. LeRoy [Abstr. 3132 (1951)]. The value obtained is $6{\cdot}3 \times 10^{-19}$ cm^3 mole^{-1} sec^{-1}, which is bigger than any value found by others. The activation energy and the steric factor of this reaction are calculated. A. J. TAYLOR

541.124

3057. The reaction of ethyl radicals with deuterium. M. H. J. WIJNEN AND E. W. R. STEACIE. *J. Chem. Phys.*, **20,** 205–7 (*Feb.*, 1952).

The ethyl radicals were produced by photodecomposition of diethyl ketone. Activation energy $E = 13{\cdot}3 \pm 0{\cdot}5$ kcal. From this value it may be concluded that the activation energy is about $11{\cdot}5 \pm 1$ kcal for the reaction of ethyl radicals with hydrogen. A.

541.124

3058. The kinetics of the fast gas-phase reaction between nitryl chloride and nitric oxide. E. C. FREILING, H. S. JOHNSTON AND R. A. OGG, JR. *J. Chem. Phys.*, **20,** 327–9 (*Feb.*, 1952).

The kinetics of the fast reaction between nitryl chloride and nitric oxide has been studied by absorptiometric methods in two systems of greatly different surface-to-volume ratio and over a temperature range from 1° to 71°. The pressure of each reactant has been varied from 0·1 mm to 18 mm and the total pressure from 0·2 mm to 384 mm. The reaction proceeds quantitatively according to the equation $ClNO_2 + NO = NO_2 + ClNO$. It is homogeneous and first order with respect to each reactant. The second-order rate constant is expressed by the equation $k = 0{\cdot}83 \times 10^{12} \exp(-6\,900/RT)$cc mole^{-1} sec^{-1}. An elementary bimolecular mechanism is proposed. A.

541.126

3059. Kinetics of the hydrogen/oxygen reaction. II. The explosion region in salt- and alkali-coated vessels. D. R. WARREN. *Proc. Roy. Soc. A*, **211,** 86–95 (*Feb.* 7, 1952).

For Pt I, see Abstr. 2118 (1951). The 1st, 2nd and 3rd explosion limits for the H/O reaction have been examined over a wide range of temperature, mixture

composition, vessel size and wall coating. An expression has been derived from general chain theory which can account for the observed features of the complete explosion region. It includes and relates previously given expressions for the individual limits. The reactions found to be necessary and apparently sufficient to account for the H/O spontaneous ignition peninsula are those of chain destruction in triple collisions, destruction at the wall of 3 different chain carriers, 1st-order branching, 2nd-order branching, the regeneration of "dead" chains and a chain-initiating process. A.

541.126

3060. Kinetics of the hydrogen/oxygen reaction. III. The explosion-limit equation and its applications. D. R. WARREN. *Proc. Roy. Soc. A*, **211**, 96–109 (*Feb.* 7, 1952).

The explosion-limit equation is considered term by term for the evaluation of the various constants and a comparison of the experimental figures with theoretical expectations. In general, the agreement is found to be satisfactory and the equation adequate in describing the whole observed region of spontaneous ignition. Certain features of the reaction about which there still exists some uncertainty are re-examined in the light of the present work. The aspects considered are those of vessel-size effects, the overall reaction mechanism, activation energy of the branching process, surface chain-breaking efficiencies, effects of inert gases and the action of sensitizers. A.

541.126 : 535.338

3061. Kinetics of OH radicals from flame emission spectra. IV. A study of the hydrogen-oxygen flame. H. P. BROIDA AND K. R. SHULER. *J. Chem. Phys.*, **20**, 168–74 (*Jan.*, 1952).

The inner and outer cones of hydrogen-oxygen flames burning lean (1 : 1), stoichiometric (2 : 1) and rich (4 : 1, 6 : 1) at atmospheric pressure have been studied spectroscopically with the object of gaining some information as to the elementary processes occurring in this flame. The rotational, vibrational and electronic distribution of $OH(^2\Sigma^+)$ has been determined for both the inner and outer cone of each fuel mixture. A thermal equilibrium distribution of the internal degrees of freedom was found for $OH(^2\Sigma^+)$ in the outer cones for all fuel ratios; in the inner cones there was a vibrational non-equilibrium distribution indicated by an excess population of the levels $v' = 2$ and 3. It is suggested that this non-equilibrium may be due to a radiationless transition reaction involving H or O atoms in excess of their thermal concentrations. This assumes, in agreement with the suggestion of Gaydon and Wolfhard, that the $^2\Sigma^+$ state of OH is weakly predissociated between the levels $v' = 2$ and 3 by a $^2\Sigma^-$ state. The possible significance of this excess atomic concentration for the active particle diffusion theory of flame propagation is indicated briefly. It is concluded that the radiation of $OH(^2\Sigma^+)$ in the oxy-hydrogen flame is predominantly thermal. [For Pt III, see Abstr. 8287 (1951)]. A.

541.126 : 541.14 : 535.343

3062. Spectroscopic studies of the hydrogen-oxygen explosion initiated by the flash photolysis of nitrogen dioxide. R. G. W. NORRISH AND G. PORTER. *Proc. Roy. Soc. A*, **210**, 439–60 (*Jan.* 22, 1952).

The method of flash photolysis has been used to initiate the reaction between hydrogen and oxygen, using a small amount of NO_2 as sensitizer. The dependence of the ignition limits on total pressure, capacity and the pressure of NO_2 have been studied, as well as the flash photochemical decomposition of NO_2 alone. The explosive reaction is complete in a few milliseconds, and very short induction periods are found whose duration can be explained in terms of the initial temperature rise. It is shown that the initiation of the explosion in this way is reproducible to less than 10^{-4} sec and flash spectroscopy is used to study the development of the reactions with time. The spectra obtained are described and the reactions of the OH radical are investigated by means of its absorption spectrum, whose intensity variations with partial pressure of H, O, N and water vapour over time intervals of 0·2 min throughout the reaction are given. Addition of H accelerates the reaction, but O in excess has the same effect as an inert gas, which is to decrease the rate. It is shown that the important propagation steps are exclusively bimolecular and the main reactions of the OH radical are identified. The mechanism of the overall explosion reaction is discussed and a reaction scheme is given which is in accordance with the results. A.

541.127

3063. Kinetics of decomposition of nitric oxide at elevated temperatures. I. Rate measurements in a quartz vessel. H. WISE AND M. F. FRECH. *J. Chem. Phys.*, **20**, 22–4 (*Jan.*, 1952).

The rate of thermal decomposition of nitric oxide has been measured in a quartz vessel from 872 to 1 275°K. The reaction follows a second-order rate law over the range of temperatures studied. Variations in the surface-to-volume ratio of the reaction vessel indicate the predominance of a heterogeneous mechanism at temperatures below 1 000°K, whereas at higher temperatures a homogeneous mechanism prevails. The experimental data are interpreted on the basis of the relative contribution of the heterogeneous and homogeneous mechanisms to the overall kinetics. Such an analysis explains the variation in effective activation energy with temperature from a value of 21·4 kcal below 1 000°K to 82 kcal above 1 600°K. An intermediate temperature region exists in which both mechanisms contribute an important part to the overall rate. A.

541.127

3064. Decomposition of *di-t*-butyl peroxide and kinetics of the gas phase reaction of *t*-butoxy radicals in the presence of ethylenimine. R. K. BRINTON AND D. H. VOLMAN. *J. Chem. Phys.*, **20**, 25–8 (*Jan.*, 1952).

The reaction of di-*t*-butyl peroxide with ethylenimine has been studied between 129° and 154°C. The rate constant for the unimolecular decomposition of the peroxide into *t*-butoxy radicals is found to be in the range $k_1 = 6 \times 10^{14} e^{-36,000/RT}$ to $k_1 = 6 \times 10^{16} e^{-40,000/RT}$ sec^{-1}. The activation energies $E_4 - E_3/2 = 4 \cdot 8$ kcal/mole and $E_2 - E_5 = 12$ kcal/mole are calculated from the kinetic data. The complete rate expression for the capture of imine H atom by CH_3 radical, $k_4 = 4 \cdot 5 \times 10^{10} e^{-4800/RT}$ $(moles/cc)^{-1}$ sec^{-1}, is

btained by using Gomer and Kistiakowsky's values or $k_3 = 4{\cdot}5\times10^{13}$ (moles/cc)$^{-1}$ sec^{-1} and $E_3 = 0$. he activation energy for the thermal decomposition f *t*-butoxy radical is about 17 kcal/mole if E_4 and E_5 f similar type H capture mechanisms are assumed qual. A.

541.127 : 542.938

3065. The kinetics of the acid and alkaline hydrolysis f methyl fluoride in water. D. N. Glew and E. A. Moelwyn-Hughes. *Proc. Roy. Soc. A*, **211**, 254–65 *Feb.* 21, 1952).

The results are compared with the data available n the other methyl halides. The mechanism of the nionic reaction is discussed in terms of a hypothesis ccording to which the rate-determining step is the artial desolvation of the ion. This mechanism is xtended to account also for the kinetic features of the ydrolysis. A.

541.128

3066. The catalytic conversion of parahydrogen by aramagnetic complex ions in aqueous solution. W. K. Wilmarth and C. F. Baes, Jr. *J. Chem. Phys.*, **20**, 116–21 (*Jan.*, 1952).

Rates of conversion of parahydrogen by paragnetic complex ions of Cu II and Cr III in aqueous olution have been measured at 25°C. The results are iscussed in terms of the Wigner theory, which predicts the effects of magnetic moment and collision istance. Owing to the planar configuration of the Cu II complexes, only a qualitative test of theoretical redictions is possible. The rate effects produced by various symmetrical octahedral complexes of Cr III an be explained in terms of the theory if one evaluates he various collision distances for H_2 from a detailed xamination of the complex structure in each case. A.

541.128 : 542.944

3067. Kinetics of the base-catalyzed halogenation of 2-carbethoxycyclohexanone. R. P. Bell and H. L. Goldsmith. *Proc. Roy. Soc. A*, **210**, 322–6 (*Jan.* 7, 1952).

The kinetics of iodination of 2-carbethoxycyclohexanone have been studied colorimetrically in aqueous buffer solutions. The reaction is of the first order with respect to the ester, of zero order with respect to iodine, and is catalysed by water molecules and by the anions of carboxylic acids. The catalytic constants of four carboxylate anions obey a relation of the Brönsted type, the exponent of which conforms to regularities previously established for a series of ketones and esters. Under comparable conditions 2-carbethoxycyclohexanone is halogenated 100 to 400 times more slowly than is 2-carbethoxycyclopentanone. This difference is in the opposite direction to that anticipated on the basis of ring strain, though it is paralleled by some other observations on 5- and 6-membered rings. A.

ELECTROCHEMISTRY 541.13

541.135 : 530.162

3068. On the free energy of a mixture of ions: an extension of Kramers' theory. T. H. Berlin and E. W. Montroll. *J. Chem. Phys.*, **20**, 75–84 (*Jan.*, 1952).

A theory of electrolytes founded on the principles of statistical mechanics is presented. The primary physical assumptions are: (1) point ions, and (2) small fluctuations. The theory is a modification of Kramers' theory of electrolytes. The modification consists of a more physically accurate development of assumption (2). The main result of the present theory is that a partition function for the electrolyte is obtained for all concentrations, whereas Kramers' theory breaks down beyond a limiting concentration. The deviation from the Debye–Hueckel limiting law is in the direction of the experimental observations. A.

541.135 : 533.15

An experimental investigation of the diffusion of electrolytic hydrogen through metals. *See Abstr.* 2478

541.135 : 621.314.64

3069. The mechanism of electrolytic rectification. H. E. Haring. *J. Electrochem. Soc.*, **99**, 30–7 (*Jan.*, 1952).

An electrochemical theory is proposed for rectification, as exemplified by the Ta (or Al) electrolytic rectifier and capacitor. A detailed consideration of the mechanism of formation of the oxide film which constitutes the rectification barrier leads to the conclusion that this barrier consists of an electrolytic polarization, in the form of a concentration gradient of excess metal ions, permanently fixed or "frozen" in position in an otherwise insulating matrix of electrolytically-formed oxide. The physical structure which has been described functions as (*a*) a current-blocking *ionic* space charge or (*b*) a current-passing *electronic* semiconductor, depending solely upon the direction of the applied voltage. The movement of electrons only is required. An explanation for breakdown of the barrier at excessively high voltages is suggested. This explanation may be applicable to dielectric breakdown of other kinds. A.

541.135.5

3070. Diffusion-type non-polarizable electrodes. S. Ya. Turlygin and N. A. Karelina. *Dokl. Akad. Nauk SSSR*, **79**, 965–8 (*No.* 6, 1951) *In Russian.*

A detailed illustrated description of a new non-polarizable $Zn/ZnSO_4$ electrode, its theory and operation. It is claimed that the electrode is stable and protected against penetration of other ions; as, moreover, the results are reproducible, telluric currents can be easily studied. F. LACHMAN

541.135.5

3071. Effect of temperature on the irreversible electrode potential of aluminium. V. V. Romanov and G. V. Akimov. *Dokl. Akad. Nauk SSSR*, **79**, 989–91 (*No.* 6, 1951) *In Russian.*

The results of tests are presented in the form of graphs. The NaCl solutions had *p*H varying from 1 to 13; the temperature range was 0–80°C. In the neutral and acid solutions the increase of temperature changes the irreversible potential of the metal towards the more negative values (linearly for $p\text{H} = 1$). In alkaline solutions the temperature dependence is complicated, and the potential values change in time more than in the case of neutral and acid solutions. F. LACHMAN

541.138 : 620.197.5

3072. Contribution to the theory of cathodic protection. C. WAGNER. *J. Electrochem. Soc.*, **99**, 1–12 (*Jan.*, 1952).

The distribution of the electrical potential inside an electrolytic solution is calculated for typical cases of cathodic protection with the aid of an auxiliary metal to be sacrificed. These calculations are used to work out equations and diagrams which permit prediction of the maximum extension of metallic surfaces for which cathodic protection can be accomplished. Decisive factors are (*a*) the electrical conductivity of the corroding solution, and (*b*) the current density for the cathodic reduction of oxidizers present. The latter value is assumed to be determined by the diffusion rate of the oxidizer from the bulk solution toward the metallic surface to be protected. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14

3073. Photochemical studies. XLVI. Photosensitization by benzene and pyridine vapors. J. T. DUBOIS AND W. A. NOYES, JR. *J. Chem. Phys.*, **19**, 1512–16 (*Dec.*, 1951).

Attempts to sensitize the dissociations of the following molecules by means of benzene vapour have been made: H, O, HCl, N_2O, methyl chloride, bromide and iodide. Positive results were obtained only with methyl iodide. The decompositions of methyl chloride and methyl bromine sensitized by pyridine vapour were also studied with negative results. The reasons for the results are discussed briefly. A.

541.14

3074. Effect of light on the solution in chloroform of iridium-1.2.6-tripyridine trichloride. II. M. DELÉPINE. *C. R. Acad. Sci.* [*Paris*] **233**, 1533–6 (*Dec.* 19, 1951) *In French.*

For Pt I, see Abstr. 1277 (1952). It has been found that, in the presence of water, more $Ir(OH_2)Py_2Cl_3$ is formed, while HCl favours the formation of $(IrPy_2Cl_4)PyH$. F. LACHMAN

541.14

3075. Free radical processes in the photolysis of acetone. S. W. BENSON AND C. W. FALTERMAN. Letter in *J. Chem. Phys.*, **20**, 201–2 (*Jan.*, 1952).

It was found, using heavy and ordinary acetone, that ethane obtained by its photolysis at 4 temperatures and 2 wavelengths showed a distribution which corresponded closely to that predicted for a completely free radical mechanism. F. LACHMAN

541.14

3076. The photo-degradation of polymethylmethacrylate. I. The mechanism of degradation. P. R. E. J. COWLEY AND H. W. MELVILLE. *Proc. Roy. Soc. A*, **210**, 461–81 (*Jan.* 22, 1952).

On exposure to ultraviolet light of wavelength 2 537 Å, polymethylmethacrylate degrades rapidly to monomer at temperatures above 130°C *in vacuo*. The general features of this reaction are described, and the behaviour of polymethylmethacrylate compared with that of other vinyl polymers under similar conditions. The diffusion of monomer through polymethylmethacrylate is a comparatively slow process. The effect of this on the experimental results is described, and the limited conditions under which true rates of degradation can be measured are outlined. The overall quantum efficiency of the photo-degradation reaction is greater than 10^2, and the intensity exponent about 0·5 for most samples. Number-average molecular weights of samples of degraded polymers have been measured, the results being similar to those obtained in an earlier study of the thermal-degradation. The results show that the mechanism of degradation is a true depolymerization process, involving initiation, a depropagation reaction, and (under most circumstances) mutual termination of reaction chains. A.

541.14

3077. The photo-degradation of polymethylmethacrylate. II. Evaluation of absolute rate constants for a depolymerization reaction. P. R. E. J. COWLEY AND H. W. MELVILLE. *Proc. Roy. Soc. A*, **211**, 320–34 (*March* 6, 1952).

Kinetic analysis of the photo-degradation of polymethylmethacrylate above 160°c involves the determination of 3 constants: I, the rate of initiation, k_d the rate constant for depropagation, and k_t the rate constant for termination. It is shown that I may be estimated from retardation experiments, and also from molecular-weight measurements. Determination of the lifetime of the kinetic chains using the rotating-sector technique and a continuously recording Pirani gauge makes it possible to evaluate k_d and k_t. It is shown that the value of k_d is in reasonable agreement with theoretical predictions, and leads to an acceptable value of the entropy of polymerization. k_t is abnormally small compared with radical termination reactions in dilute solution. This is interpreted as a "gel effect" due to the abnormal conditions under which the reaction occurs in a highly viscous polymer. For Pt I, see preceding abstract. A.

541.14 : 541.124

3078. Photochemistry as a tool for the study of reaction mechanism. W. A. NOYES, JR. *Proc. Amer. Phil. Soc.*, **95**, 542–3 (*No.* 5, 1951).

Photochemistry is likely to become an efficient tool for the study of certain atom and radical reactions if the careful study of the effect of the absorption of light on a given molecule results in the determination of the rates of formation of atoms and radicals. The recent relevant literature relating to the reaction of CH_3 radicals is quoted. F. LACHMAN

541.145

3079. Photochemical oxidation-reduction and photocatalysis. The photochemical activity of $FeCl_4^-$ in alcohol as oxidizing agent and as catalyst. G. J. BREALEY AND N. URI. *J. Chem. Phys.*, **20**, 257–62 (*Feb.*, 1952).

A true photocatalytic reaction in which the concentration of the sensitizer remains constant is described in this paper. It is shown that $FeCl_4^-$ acts as a photocatalyst for the oxidation of alcohol by thionine.

In the absence of thionine $FeCl_4^-$ is the oxidizing agent. A mechanism is put forward which includes (1) photoexcitation, primary dark back reaction and separation of the primary product, (2) oxidation of the CH_3CHOH radical by $FeCl_4^-$, (3) reaction between two CH_3CHOH radicals, (4) oxidation of $FeCl_4^-$ by thionine. The latter occurs because of a considerable shift in the oxidation-reduction potential by the complexing of both ferric and ferrous iron. Various constants and constant ratios are evaluated from the experimental results. A.

541.15

3080. The effect of X-ray intensity on the radiation of $KMnO_4$. L. Bloch-Frankenthal and G. Goldhaber. Letter in *Bull. Res. Coun. Israel*, **1**, 117–18 (*March*, 1951).

The reduction of $KMnO_4$ in aqueous solution (N/250) by a dose of 3×10^6 r of X-rays (H.V.L. not stated) diminishes with increasing dose rate. The effect is attributed to greater rate of recombination of radicals at the higher dose rates. C. B. Allsopp

541.15 : 537.531

3081. The action of X-rays on ferrous and ferric salts in aqueous solutions. T. Rigg, G. Stein and J. Weiss. *Proc. Roy. Soc. A*, **211**, 375–98 (*March* 6, 1952).

The H atoms and OH radicals formed primarily by the action of the radiation on the water react according to $Fe^{3+} + H \rightarrow Fe^{2+} + H^+$ and $Fe^{2+} + OH \rightarrow Fe^{3+} + OH^-$. Experiments carried out in the presence of molecular hydrogen, where the latter reaction competes with the reaction $H_2 + OH \rightarrow H_2O + H$, permit the deduction that the specific rate constant of the reaction between OH radicals and ferrous ions is about five times greater than that of the corresponding reaction with hydrogen molecules. The study of the *p*H dependence of the reaction has led to the assumption that molecular hydrogen ions, H_2^+(hydr.), intervene in this process undergoing the reaction $Fe^{2+} + H_2^+$(hydr.) $\rightarrow Fe^{3+} + H_2$, and that these ions exist in the equilibrium: $H + H^+$(hydr.) $\rightleftharpoons H_2^+$(hydr.). Experimental evidence and some theoretical considerations which have led to the assumption of H_2^+ in aqueous systems have been discussed in detail. In the presence of molecular oxygen the hydrogen atoms react according to $H + O_2 \rightarrow HO_2$, followed by reactions of the latter radical. A comparison of the experimentally determined yields under different conditions with the absolute (chemical) yields as derived from the proposed mechanism has led to the estimation of the energy (W_{H_2O}) required for the production of a radical pair (H + OH) by the action of X-rays on water. This has been found to be $W_{H_2O} = 19{\cdot}4 \pm 0{\cdot}4$ eV. A.

541.15 : 539.166.08

3082. Gamma-ray dosimetry with polyvinyl-chloride films. E. J. Henley and A. Miller. *Nucleonics*, **9**, 62–6 (*Dec.*, 1951).

The method is based upon the alteration in colour of a dye in the p.v.c. film as a result of release of HCl through the action of radiation. The dosimeters consist of 0·0016 in thick polyvinyl films in which a methyl-violet dye is distributed. Irradiation results in a change of colour from violet to blue and then to yellow-orange. Spectrophotometric measurements on a 600 mμ absorption maximum were made and the transmission of this wavelength through the films used to measure the fraction of dyestuff converted. Experiments were carried out with 250 keV and 2 MeV X-rays and Ta^{182} and Co^{60} γ-rays. It was found that the rate of conversion of dyestuff was proportional to the amount of unconverted dye for small dosages but not with large dosages owing to changes in composition of the residual p.v.c. The system is effective in the range 5×10^5 to 10^7 r. L. R. Shepherd

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.182.3

3083. The formation of an aerosol by condensation of a dilute vapour in a carrier gas. J. Corner. *Proc. Roy. Soc. A*, **211**, 417–30 (*March* 6, 1952).

The formation of a dilute aerosol by supercooling a mixture of vapour and carrier gas is examined theoretically. It is shown how the partial differential equations of this kind of problem can be reduced approximately to a set of ordinary differential equations, much more easily handled by numerical methods. An approximate solution is obtained which shows how the average particle size depends on the rate of cooling and the time of quenching. A.

541.183

3084. On the adsorption in dilute solution hydrochloric acid and sodium hydroxide by active carbon. H. Erkut. *Istanbul Univ. Fen. Fac. Mek. Ser. A*, **16**, 200–20 (*July*, 1951).

This has been studied by an electrolytic method, which gives results of considerable accuracy in spite of the great dilutions used. The results are well represented by the equation of Freundlich, and a physical interpretation is given of the meaning of the constants of this adsorption equation. Values of the heat of adsorption and the affinity of adsorption are calculated and it is concluded that mainly physical adsorption takes place. Estimates of the area of surface are made by a new method, and it is shown that only a small fraction of the surface adsorbs. A.

CHEMICAL STRUCTURE 541.2/.6

541.553

3085. Calculation of the intensities of orbital and orientation of directed valencies in the pure forms of hybridization. S. Senent and F. Senent. *An. Real Soc. Esp. Fis. y Quim. A*, **47**, 197–204 (*Sept.–Oct.*, 1951) *In Spanish.*

See Abstr. 9793 (1951). The values are discussed and tabulated for all pure hybridizations theoretically possible, enabling a system to be deduced. A.

541.553

3086. Designation of the geometrical form corresponding to each electronic configuration. S. SENENT AND F. SENENT. *An. Real Soc. Esp. Fis. y Quim. A*, **47**, 205–10 (*Sept.–Oct.*, 1951) *In Spanish.*

In order to resolve the ambiguity due to the fact that various electronic configurations are possible for one geometrical form, the concept of hybridization intensity is introduced, to be understood as a summary of all the orbital intensities of all the valences in pure and mixed forms. Each geometrical form is given the electronic configuration of the highest hybridization intensity, after 5 other possible electronic configurations, known by the expression electronic defect, have been introduced. A.

541.553

3087. Method of assigning the spatial morphology to the central atom of an atomic aggregate. S. SENENT AND F. SENENT. *An. Real Soc. Esp. Fis. y Quim. A*, **47**, 211–20 (*Sept.–Oct.*, 1951) *In Spanish.*

Sets forth a series of rules for the spatial morphology of an atomic aggregate, from its chemical composition, the apolar character of the chemical bonds and the co-ordination number. These rules permit the electronic configuration of the central atom and its morphology to be obtained. This helps to resolve the problem of the knowledge of the semi-ionic character of chemical bonds and to fix the limit forms permitted by resonance. A.

541.57 : 539.13

3088. An interpretation of bond lengths and a classification of bonds. R. T. SANDERSON. *Science*, **114**, 670–2 (*Dec.* 21, 1951).

Expansion and contraction of electron spheres lead to "adjusted" atomic radii. A measure of electronegativity is the function of atomic radius "stability ratio": the ratio of electron density of atoms and ions of active elements to that of an inert atom with same number of electrons. Evaluation of this ratio led to a determination of effective atomic radii in some 700 bonds. J. JACOBS

541.57 : 539.132

Molecular orbital theory of chemical valency—the interaction of paired electrons in chemical bonds. *See Abstr.* 2888

541.57

3089. Electron deficient compounds. VI. The structure of beryllium chloride. R. E. RUNDLE AND P. H. LEWIS. *J. Chem. Phys.*, **20**, 132–4 (*Jan.*, 1952).

The simple compound, beryllium chloride, offers an opportunity to study halogen bridge bonding. Beryllium chloride is isomorphous with dimethylberyllium and silicon disulphide. The orthorhombic unit, $\alpha_0 = 9{\cdot}86$, $b_0 = 5{\cdot}36$, $c_0 = 5{\cdot}26$ Å contains four beryllium chloride molecules. The structure consists of continuous chains with an essentially tetrahedral configuration about beryllium. The Cl–Be–Cl bond angle within the four membered rings is 98·2° which is less than the tetrahedral angle, as is found in SiS_2, instead of more, as in dimethylberyllium. The bond angles indicate that all bonds in beryllium chloride contain an electron pair, so that chlorine uses an unshared pair in forming bridge bonds. Hence, chlorides isomorphous with electron-deficient metal alkyls are not to be classified as electron-deficient compounds. A.

541.65

3090. Visible fluorescence and chemical constitution of compounds of the benzo-pyrone group. IV. Further study of γ-pyrone derivatives. V. V. S. MURTI, S. RAJAGOPALAN AND L. R. ROW. *Proc. Indian Acad. Sci. A*, **34**, 319–23 (*Nov.*, 1951).

A large number of chromones, flavones, flavanones and isoflavones have been examined for fluorescence in sulphuric acid solution. With the chromone derivatives the relationship between fluorescence and chemical constitution seems to be almost the same as that found with the coumarins [see Abstr. 119 (1943)], but the chromones show a greater tendency to fluoresce. The pyrone double bond is essential for fluorescence. It is suggested that the real fluorescent substances in acid solution are the pyronium or hydroxy-pyrylium salts, into which the γ-pyrone structure changes. A. J. MEE

CHEMICAL PROCESSES 542.9

542.92 : 537.311.33

3091. The thermal decomposition of lithium aluminium hydride. W. E. GARNER AND E. W. HAYCOCK. *Proc. Roy. Soc. A*, **211**, 335–51 (*March* 6, 1952).

$LiAlH_4$ on heating decomposes in three stages: (*a*) an initial surface reaction during the induction period, followed by (*b*) an interface reaction giving an S-shaped pressure against time curve, corresponding to $LiAlH_4 \rightharpoonup LiAlH_2 + H_2$, and (*c*) a slow process during which a 3rd H atom is liberated. The initial reaction is rapid at first and then slows down to a constant rate. It occurs to the extent of about 0·7% of the total decomposition and penetrates the surface to a depth of several molecular layers. Its activation energy is 22 kcal. The interface reaction obeys a cube-root plot and has an activation energy of 25 kcal. The electrical conductivity of $LiAlH_4$ has a positive temperature coefficient with an activation energy of 16 kcal. During the thermal decomposition there is a maximum on the electrical conductivity curve, occurring early in the initial surface reaction. The conductivity at the maximum is 10 times greater than that extrapolated from the natural conductivity. It is concluded that conductivity arising during the thermal decomposition is, in the main, due to defects produced during the initial surface reaction; also, that the formation of nuclei is a two-stage process consisting (*a*) of the aggregation of defects at lattice discontinuities followed by (*b*) the collapse of the defect aggregate to give nuclei at which a normal interface reaction proceeds. A.

542.952

3092. Contribution to the study of polymerization of ethylene under the influence of electric discharges. W. MUND AND R. COEKELBERGS. *Ann. Soc. Sci. Brux.* (*Sér.* 1) **65**, 149–87 (*Dec.*, 1951) *In French.*

The reaction products, gaseous and liquid, are analysed physically and chemically; the average

molecular weight and the average number of double bonds of each fraction are determined and Raman spectra are taken. A great number of aliphatic and cyclic compounds, among them menthene, are found. To obtain these several reactions must take place at the same time, which can be explained by assuming that at first radicals are formed, which can combine in various ways. A. J. TAYLOR

542.952.7 : 534.39

3093. Depolymerization by ultrasound. R. O. PRUDHOMME. *Nuovo Cim.*, 7, 278–83 (*Suppl. No.* 2, 1950) *In French.*

Experiments have been made in which the thermal effect of ultrasound was eliminated, and the rate of depolymerization was recorded both with and without gases present likely to assist chemical reactions—the rate was independent of the gas (the material studied was an aqueous solution of carboxymethylcellulose). A mixture of 1% polystyrolene in toluene, when tested after deaeration, showed no change of viscosity after 1 hour's treatment with ultrasound, but considerable change occurred when cavitation was permitted in the liquid. Similar results were obtained with carboxymethylcellulose in water. An electric stirrer operating at 15 000 r.p.m. was tried to see whether the agitation it produced would assist depolymerization—more than 10 min stirring affected the viscosity of a carboxymethylcellulose solution, but a very much greater effect was produced by ultrasonic treatment at 960 kc/s. A. C. WHIFFIN

CHEMICAL ANALYSIS 543/545

545.8 : 539.16

3094. Radioassay of potassium in solid samples. O. J. RUSSELL. *Brit. J. Appl. Phys.*, 3, 47–50 (*Feb.*, 1952).

Powdered samples are assayed for K by the use of a Geiger counter designed for liquid samples. With precautions, the statistical accuracy expected in considerations of counting random events is achieved satisfactorily. A pure K compound is employed as an "absolute" standard of K content, obviating the use of calibrating solutions or synthetic standard mixtures. Full advantage of this is taken by employing a density correction, so that the use of an effectively "infinite" sample thickness, and hence large amounts of sample, is avoided. Unexpectedly, interference was experienced from U present in the phosphatic constituents of fertilizer samples tested. It was found possible to correct for this, and obtain satisfactory agreement with chemical determinations. The manipulation of powders instead of preparing solutions has advantages in rapidity for routine commercial or geological examination of many samples. Accuracy and sensitivity depend upon the usual statistical considerations encountered in radioactivity measurements. Good sensitivity and accuracy are attained without long counting periods, and it is considered that further developments are likely. A.

545.82 : 535.247.4

3095. Internal standard flame photometry. E. G. WALSH. *J. Sci. Instrum.*, 29, 23–4 (*Jan.*, 1952).

The author's colour wedge photometer has been used to study some aspects of flame photometry as applied to chemical analysis. It has been shown that convenient calibration curves may be obtained with this method. Studies have also been made of the effect of foreign substances and of the optimum operating conditions of the flame. A.

545.822

3096. Spectroscopic analysis of deuterium in hydrogen-deuterium mixtures. H. P. BROIDA AND J. W. MOYER. *J. Opt. Soc. Amer.*, 42, 37–41 (*Jan.*, 1952).

Gaseous mixtures of H and D from 85 to 100% D were rapidly analysed spectroscopically to within 0·1% of the major component. A 150 Mc/s electrodeless discharge in flowing gas was used. Under typical conditions the value of the measured intensity ratio was found to vary with pressure in an unexplained manner. The addition of air up to 2·5% did not affect the measured isotope ratio. A.

CRYSTALLOGRAPHY 548

548.0 : 535.581

Contribution to the study of the optical properties of crystals of Seignette salt. *See Abstr.* 2653

548.5

3097. Crystallization. C. S. GROVE, JR AND J. B. GRAY. *Industr. Engng Chem.*, 44, 41–5 (*Jan.*, 1952).

Review of papers and books published in 1951 (81 refs.).

548.5

3098. Crystal growth and dislocations. F. C. FRANK. *Adv. Phys.*, 1, 91–108 (*Jan.*, 1952).

It is shown theoretically that a perfect crystal could not grow at a measurable rate unless the vapour in contact with it were supersaturated to ~25% or even more, and that the rate of growth would increase non-linearly and very rapidly with higher supersaturation. This is because of the difficulty of starting nuclei on a plane face for a fresh layer of molecules to form. But if a crystal contains a screw dislocation, the face on which this ends must always have a step radiating from the dislocation axis, and growth can take place continuously on this step, needing only a small degree of supersaturation to promote it. The step would form a spiral round the dislocation axis. Electron, phase-contrast and interference micrographs are reproduced to show these spiral growth steps on beryl, the paraffin $C_{36}H_{74}$, carborundum and cadmium iodide. A. R. STOKES

548.5

3099. Growth spirals on gold crystals obtained by precipitation. S. Amelinckx, C. C. Grosjean and W. Dekeyser. *C.R. Acad. Sci.* [*Paris*] **234,** 113–15 (*Jan.* 2, 1952) *In French.*

Triangular spirals were observed on the (111) face of Au crystals of 10–30 μ. Their visibility indicates that the Burgers vector is a relatively large multiple of one unit cell. The preparation of the crystals is described. J. A. FRANKS

548.5

3100. Oriented chemical overgrowths and surface topography. D. W. Pashley. *Proc. Roy. Soc. A,* **210,** 354–76 (*Jan.* 7, 1952).

The growth of thin halide tarnish layers on Ag crystals has been studied. The substrate surfaces were prepared in various ways, so that their topography could be varied. By a careful analysis of electron-diffraction patterns from the specimens, it has been possible to deduce the true contact planes between Ag and halide for many of the observed orientations of Ag halide. The contact planes were often not parallel to the macroscopic surface of the substrate. To a large extent, the orientation of the halide on the (*hkl*) type Ag facets was independent of the position of those facets with respect to the macroscopic surface. There is evidence, however, that certain orientations on a given (*hkl*) facet only occur provided that facet contains some irregularities (probably steps or cracks), along which the growth can originate. Some unexplained disorientation effects are observed, and some examples of orientations corresponding to large percentage misfit between substrate and overgrowth are also given. A.

548.5 : 536.422.15

3101. The rates of evaporation from different faces of rhombic sulphur. E. Rideal and P. M. Wiggins. *Proc. Roy. Soc. A,* **210,** 291–309 (*Jan.* 7, 1952).

The evaporation pressures of 4 faces of rhombic S have been measured by a method which is a modification of the effusion technique for the measurement of vapour pressures of solids. The results in the temperature range 20 to 40°c show that each face has a characteristic, reproducible evaporation pressure, irrespective of the conditions under which the crystal was grown; that this evaporation pressure varies from face to face of the crystal; and that the activation energy for evaporation also varies, increasing with the reticular density of the face. From a consideration of the processes occurring at the crystal surface during evaporation, it was concluded that the condensation coefficients of the 4 faces are different, and that they have characteristic temperature coefficients. This was supported by some data on the growth form of crystals grown from solution at different temperatures, and it was concluded that it is possible that these 4 faces, with widely differing rates of evaporation, are all equilibrium faces of the crystal. Discontinuities were found to occur in the curves of log P against $1/T$ for 2 of the 4 faces above 40°c. It was suggested that these are due to the onset of rotation on the crystal surfaces at the temperatures concerned, and that for each face a transition occurs at the temperature at which its condensation coefficient reaches unity. The mechanism of evaporation proposed assumes that an evaporating surface always has an inexhaustible supply of molecular terraces and that the rate of evaporation is controlled by the rate of formation of "kinks" on the edge of such a step. Two faces of the crystal were investigated at temperatures above 90°c. Transitions were found to occur in each case at a temperature below that of the transformation of the rhombic into the monoclinic lattice. This was interpreted as a formation of monoclinic crystallites on the rhombic surface. A.

MOLECULAR AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

3102. Heat capacity and lattice defects of silver chloride. K. Kobayashi. Letter in *Phys. Rev.,* **85,** 150–1 (*Jan.* 1, 1952).

AgCl shows an abnormal increase in heat capacity above 700°K. The heat of activation for formation of lattice defects is estimated at various temperatures. It is suggested that defects in AgCl are generally of Frenkel nature, but that the excess in enthalpy is caused by Schottky defects. A. J. TAYLOR

548.7

3103. A study of selection rules for vibrational spectra of complex crystals. T. H. Walnut. *J. Chem. Phys.,* **20,** 58–62 (*Jan.,* 1952).

Relations are obtained for the expression of the dipole moment and polarizability matrices for a particular transition in a crystal in terms of corresponding expressions for molecular or ionic groups within the crystal. The results show that, to the degree of approximation used (quadratic terms in the dipole moment or polarizability expansion and cubic terms in the potential energy), the only cause for the appearance of bands which would be forbidden for a given uncoupled complex ionic or molecular group is the alteration of the normal co-ordinates of these groups by vibrations of neighbouring groups. It is also shown that the bands of fully allowed first overtones and binary combinations of frequencies that are not degenerate or near-degenerate in a unit cell have a shape that is approximately given from the distributions of frequencies that arise from lattice coupling. As an incidental result, the dipole moment matrix elements for the first overtones and binary combinations arising from the cubic terms in the potential energy are given explicitly. A.

548.7

3104. The frequencies and the anharmonicities of the normal modes of oscillation of alkali halide crystals. II. Low-frequency acoustic modes. K. S. Krishnan and S. K. Roy. *Proc. Roy. Soc. A,* **210,** 481–97 (*Jan.* 22, 1952).

For Pt I, see Abstr. 7379 (1951). In the present part are deduced, on the basis of Born's model, expressions for the frequency and the ratio of the amplitudes of the alkali and the halide ions in an alkali halide crystal, for any general normal mode of oscillation of the crystal. The results are applied in detail to the special case of low-frequency acoustic modes. Since the amplitudes

of the two ions are not in general the same, there is a resultant electric polarization of the medium accompanying the oscillations, and consequently a polarization field. The force acting on an ion due to this field is found to be comparable with the force of interaction with the other ions, not only in the optical branch, in which the displacements of adjacent positive and negative ions are in opposite directions and in which, therefore, the polarization is large, but also in general in the acoustic branch, in which their displacements are in the same direction. A detailed calculation, however, shows that for low frequency acoustic modes, though the ratio of the amplitudes of the two ions is affected by the polarization field, the frequency remains completely unaffected by it. The expressions deduced for the frequencies of the acoustic modes give also the velocities of propagation of the corresponding acoustic waves, and since the latter are already known in terms of the elastic constants of the crystal, simple expressions for these constants are obtained. The elastic constants so calculated are found to agree with observation. Unlike the principal oscillation of the crystal dealt with in Pt I, these low-frequency acoustic modes have negligible anharmonicity. A.

548.7

3105. The frequency spectrum of a two-dimensional ionic lattice. M. SMOLLETT. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 109–15 (*Feb.*, 1952).

The frequency spectrum of a two-dimensional ionic lattice has been evaluated. A method is given for calculating the exact density of the spectrum at special points in phase space. Two logarithmic infinities, first found by Montroll using a quasi-elastic forces model, are confirmed for an ionic lattice. The bearing of these infinities on the interpretation of the second-order Raman spectra is discussed. A.

548.7 : 535.343.2–15

3106. Measurements with crystals using polarized infra-red radiation. J. MANN AND H. W. THOMPSON. *Proc. Roy. Soc. A*, **211**, 168–82 (*Feb.* 21, 1952).

A method is described for the measurement of the infrared absorption spectra of crystals and other crystalline materials using polarized radiation. From the variation in intensity of vibration bands as the crystals are rotated with respect to the incident radiation vector, a partial determination of the crystal structure can be made, and the results can be compared with those obtained from X-ray measurements. Alternatively, in some cases, an assignment of vibration frequencies to particular classes of normal modes can be made. The conclusions agree with those reached by X-ray analysis in most cases, but in paradinitrobenzene crystals it is suggested that the nitro groups are slightly twisted out of the plane of the aromatic rings. Some general factors affecting the scope of this method are considered. A.

548.7 : 535.376

On the scintillation mechanism in organic crystals. *See Abstr.* 2647

548.7 : 535.55 : 535.375.5

Relation between photo-elastic properties and Raman effect in crystals. *See Abstr.* 2644

548.7 : 539.132

3107. The interlayer binding in graphite. R. O. BRENNAN. *J. Chem. Phys.*, **20**, 40–8 (*Jan.*, 1952).

The repulsive energy between layers of the graphite crystal has been calculated as an interaction of *LCAO* molecular orbitals in the layers. The van der Waals attractive term was found by setting the energy minimum to fall at 3·37 Å. When values of the effective nuclear charge and effective quantum number proposed by Kohlrausch were used, the interlayer binding energy was found to be 3·99 kcal/mole. The compressibility, calculated under plausible assumptions, is in satisfactory agreement with the experimental value. A.

548.73/.74 : 539.26/.27

X-ray and electron investigation of materials. *See Abstr.* 3020–1, 3023–4

548.732

3108. On the problem of focusing diffracted X-rays on an oblique flat film. F. BUCKENS. *Brit. J. Appl. Phys.*, **3**, 7–10 (*Jan.*, 1952).

A geometrical treatment of focusing in the X-ray back-reflection method is given. The form of the irradiated surface, the breadth of the emitting source, and the size and location of the limiting diaphragm are considered. A theory of "secondary focusing" is suggested, with experimental support. The idea can be used for effecting focusing on both sides of an oblique flat film. A.

548.733

3109. The adaptation of a Geiger counter to the Weissenberg camera. D. F. CLIFTON, A. FILLER AND D. MCLACHLAN. *Rev. Sci. Instrum.*, **22**, 1024–5 (*Dec.*, 1951).

An attachment to a standard camera, for setting the Geiger counter to appropriate Bragg angles, is described. A. R. STOKES

548.734

3110. The analysis of crystals by divergent X-rays. K. LONSDALE AND J. L. AMORÓS. *An. Real Soc. Esp. Fis. y Quim. A*, **47**, 251–6 (*Sept.–Oct.*, 1951) *In Spanish.*

Special attention is paid to the tube designed by Müller with which X-rays with a divergence of 180° may be obtained. Several crystals of organic substances are tested. A.

548.734.8

3111. An improved positive print method for measuring integrated intensities of X-ray diffraction patterns. R. L. GRIFFITH. *J. Opt. Soc. Amer.*, **42**, 31–3 (*Jan.*, 1952).

The requirements of a satisfactory positive print method of measuring integrated X-ray diffraction intensities are discussed. An improved positive print process which covers a larger X-ray exposure range than that previously claimed for this method, and typical results obtained with it are described. Some precautions which should be observed in the application of the process are given. A.

548.734.8

3112. Theory and use of statistical methods in the determination of symmetry and structure of crystals. A. J. C. WILSON. *Nuovo Cim.*, **9**, 50–5 (*Jan.*, 1952).

Centres of symmetry, mirror planes and rotation

axes can be recognized in suitable cases through a statistical study of the intensities of the X-ray reflections. The number of essentially distinct space groups that can be determined by X-ray methods is thus raised from about 60 to 215, out of a total of 219. Statistical methods may also be of use in the study of pseudosymmetry. Applications to ephedrine and haemoglobin are described briefly. A.

548.735

3113. The question of uniqueness in the determination of crystal structures. J. GARRIDO. *Bull. Soc. Franç. Minér. Crist.*, **74**, 397–431 (*July–Sept.*, 1951) *In French.*

A structure obtained from X-ray diffraction data is unique only if no other structure can be found having (1) the same vector separations between atoms and (2) the same amplitudes of X-ray diffraction. Examples of pairs of structures satisfying (1) are given. A proposed structure can be tested for uniqueness by testing the conditions (1) and (2) in turn. The first is tested by inspecting the table of vector separations of the atoms, and if another possible structure exists, its atomic positions may readily be found. The method is illustrated by reference to several actual structures. A. R. STOKES

548.735

3114. The diffraction of X-rays by distorted-crystal aggregates. III. Remarks on the interpretation of the Fourier coefficients. J. N. EASTABROOK AND A. J. C. WILSON. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 67–75 (*Jan.*, 1952).

For Pt II, see Abstr. 6565 (1949). The line profile of the hth order reflection from a set of lattice planes is known to be given by a Fourier series with coefficients $A(h, m) = N(m)J(h, m)$. The function $N(m)$ depends on the particle shapes and sizes, and $J(h, m)$ depends on the state of strain. Neither can be completely determined from the experimental Fourier coefficients for a single value of h. They have, however, different behaviours for small m, and $A(h, m)$ has an unambiguous interpretation in this region only: its initial slope gives the mean particle thickness, and its initial curvature sets a lower limit to the mean-square strain. The practical value of this interpretation is subject to two limitations: (i) the initial shape of the $A(h, m)$ curve depends on the "tail" of the line profile, (ii) if the crystals are large enough to contain several regions of compression and extension, probability theory shows that $J(m)$ is likely to be approximately proportional to $\exp\{-\text{const.}|m|\}$ for m large. Extrapolation to small m could then tend to give fictitiously small values for both particle size and strain. The problem of obtaining the greatest possible amount of information from observed line profiles of all orders is discussed. Usually only a few orders can be measured, and the information obtainable is less, but in three special cases the Fourier coefficients of two lines can yield all information obtainable from the full set. A.

548.735.44

3115. Use of mechanical methods in the calculation of the tridimensional synthesis of Co_2Al_9. J. L. AMORÓS. *An. Real Soc. Esp. Fis. y Quim. A*, **47**, 239–50 (*Sept.–Oct.*, 1951) *In Spanish.*

The technique employed in the Cavendish Laboratory, using cards of Hollerith type, is detailed. The distribution of computations to simplify the operations is also explained. A.

548.736.3

3116. On the crystal structure of cubic rubidium nitrate. U. KORHONEN. *Ann. Acad. Sci. Fennicae, A I*, 35 *pp.* (*No.* 102, 1951) *In German.*

Accurate F values were obtained by Wasastjerna's photographic method with a powder specimen at 190°C. It was previously supposed that $RbNO_3$ had a CsCl structure, with the NO_3 groups rotating, but this model did not give satisfactory intensity agreement. With a doubled cell edge and fixed NO_3 groups good agreement is obtained: cubic, $Pa3$, $a = 8{\cdot}74$ Å, $Z = 8$, 4Rb in (a), 4Rb in (b), 8N in (c) with $x = 0{\cdot}285 \pm 1$, 24O in (d) with $x = y = 0{\cdot}228 \pm 6$, $z = 0{\cdot}399 \pm 1$. The root-mean-square displacement of the Rb atom is 0·385 Å at 190°C.

A. J. C. WILSON

548.736.3

3117. X-ray measurement of order in CuPt. C. B. WALKER. *J. Appl. Phys.*, **23**, 118–23 (*Jan.*, 1952).

In investigating the order-disorder transformation in CuPt, cell parameters were determined from specimens quenched at intervals from 25°C to 890°C. The rhombohedral deformation of the ordered, layered structure was found to diminish with increasing temperature, disappearing at a critical temperature of 815°C. Integrated intensity measurements of superstructure reflections from quenched powder and briquette samples determined that the long-range order, S, decreases slowly with increasing temperature to a value of 0·77 at T_c, where it changes abruptly to zero, with the transformation below T_c being homogeneous. A simple theory is developed relating the rhombohedral deformation to S. Cold working an ordered sample was found to transform the alloy almost completely from the ordered rhombohedral cell to the disordered cubic cell. From measurements of diffuse intensities diffracted by briquettes above T_c, Fourier transform methods determined parameters which fixed the local order as being local layering configurations, in contrast to the usual A-likes-B type of order. A.

548.736.5

3118. X-ray investigations of solid solutions of $K_2O \cdot 11Al_2O_3$ with $K_2O \cdot 11Fe_2O_3$. A. BURDESE. *Atti Accad. Sci. Torino, I*, **85**, 227–30 (1950–51) *In Italian.*

Lattice parameters (hexagonal) are given for compositions over the whole range. There are two phases between 40% and 53% by molecules of $K_2O \cdot 11Fe_2O_3$, and a single phase elsewhere. A. R. STOKES

548.736.5

3119. The crystal structure of monoclinic basic copper nitrate. W. NOWACKI AND R. SCHEIDEGGER. *Experientia*, **7**, 454 (*No.* 12, 1951) *In German.*

$Cu_4(NO_3)_2(OH)_6$ is monoclinic, $P2_1/m$, $a = 5{\cdot}576 \pm 2$, $b = 6{\cdot}050 \pm 2$, $c = 6{\cdot}896 \pm 3$ kX, $\beta = 94° 30' \pm 6'$, $D_m = 3{\cdot}32$, $Z = 1$, $D_x = 3{\cdot}33$ g/cm³. It forms a layer structure with Cu atoms in a pseudo-hexagonal net parallel to (001), each in a distorted octahedron of 6 O atoms. Detailed parameters are given. A. J. C. WILSON

548.736.5

3120. The structure of platinum oxides. E. E. GALLONI AND R. H. BUSCH. Letter in *J. Chem. Phys.*, **20**, 198–9 (*Jan.*, 1952).

It is stated that a compound prepared by Jörgensen's method should have the formula Pt_3O_4, and not Pt_3O_4Na, as is put forward by J. Waser and E. McClanahan [Abstr. 4910 (1951)]. Different formulae of Pt oxides are also suggested for substances previously investigated by other authors. The existence of anhydrous PtO is doubted. A. J. TAYLOR

548.736.5

3121. The structure of $Na_xPt_3O_4$. J. WASER AND E. D. MCCLANAHAN, JR. Letter in *J. Chem. Phys.*, **20**, 199 (*Jan.*, 1952).

In answer to E. Galloni and R. H. Busch (preceding abstract) the authors state that their compound, obtained by Jörgensen's method did contain sodium. As the Na atoms may be situated in some of the holes formed by cubes of O atoms in the crystal, a formula $Na_xPt_3O_4$ is suggested, with $0 \leqslant x \leqslant 1$. A. J. TAYLOR

548.736.5 : 538.22

3122. Solid solutions of oxides of iron and aluminium with potassium oxide: magnetic and X-ray investigations. A. BURDESE AND C. BRISI. *Atti Accad. Sci. Torino*, *I*, **85**, 231–5 (1950–51) *In Italian.*

$K_2O \cdot Al_2O_3$ and $K_2O \cdot Fe_2O_3$ show complete miscibility for all compositions. Tables showing variation of lattice parameter and magnetic susceptibility with composition are given. A. R. STOKES

548.737

3123. Crystal-structure investigation of xanthazol monohydrate. W. NOWACKI AND H. BÜRKI. *Experientia*, **7**, 454–5 (*No.* 12, 1951) *In German.*

Triclinic, $P\bar{1}$, $a = 9{\cdot}67$, $b = 10{\cdot}71$, $c = 5{\cdot}24$ Å, $\alpha = 100°\ 52'$, $\beta = 141°\ 54'$, $\gamma = 87°\ 0'$, $D_m = 1{\cdot}74$, $Z = 2$. Statistical methods indicated probable centrosymmetry, confirmed by structure determination. A three-dimensional Patterson synthesis (1 300 reflections) showed a layer structure with molecules nearly parallel to (001); of four steric possibilities (2 centrosymmetric, 2 not), only one (centrosymmetric) showed the water molecule clearly in the Fourier syntheses, and was accepted as correct. Very weak additional reflections indicate a superstructure.

A. J. C. WILSON

548.74

3124. Asymmetrical electron diffraction effects from single crystals of silver. D. W. PASHLEY. *Proc. Phys. Soc.* [*Lond.*] *A*, **64**, 1113–24 (*Dec.*, 1951).

Ag crystal surfaces which had been prepared by either electrolytic etching or electrolytic polishing were studied by means of the electron diffraction reflection technique. It was found that fine structure effects, in the form of split spots or streaks through spots, gave information concerning the topographies of the various surfaces of the crystals. The fine structure effects showed certain asymmetries which do not immediately follow from the Laue diffraction theory. The possible causes of these asymmetries are discussed, and it is concluded that they were probably due to distortion of the Ag crystals, but that some might have also been due to refraction effects. A.

548.74 : 548.538

3125. Oriented deposits on crystalline substrates. D. W. PASHLEY. *Proc. Phys. Soc.* [*Lond.*] *A*, **65**, 33–8 (*Jan.*, 1952).

Layers of Ag and Tl halides have been evaporated, *in vacuo*, on to cleavage surfaces of rocksalt, KBr, MgO and mica, at various substrate temperatures. These layers have been studied by means of electron diffraction. Examples of both high and low interatomic misfits between the substrate and the oriented overgrowth are found. In the case of AgCl on KBr, a chemical reaction occurred between the substrate and the deposit. TlCl crystallized in an abnormal rocksalt type structure on KBr, but had its normal CsCl type structure on the other substrates used. A.

GEOPHYSICS 55

550.34

3126. The Strasbourg vertical component electromagnetic seismograph. E. PETERSCHMITT. *Ann. Franç. Chronom.*, **6**, 245–8 (*No.* 3, 1951) *In French.*

The seismograph is of the conventional type in which the variations in the reluctance of a magnet circuit cause deflections of a galvanometer spot. The instrument is mounted on a platform which can be excited sinusoidally so that the magnification can readily be measured. At a frequency of 1 c/s, the amplification is of the order of 6 000. H. J. H. STARKS

550.381

3127. The representation of the main geomagnetic field and of its secular variation by means of two eccentric dipoles. H. G. MACHT. *Trans Amer. Geophys. Un*, **32**, 555–62 (*Aug.*, 1951).

On the basis of certain analytical aspects of geomagnetic potential theory, there is developed a physical model of the main geomagnetic field, consisting of two eccentric dipoles. This model, accounting exactly for the whole second-order potential portion, represents a generally improved approximation to the observed (terrestrial) surface field. The systematic displacements which both its dipoles have undergone since 1829 also suggest the existence of a superior "planetary component" in geomagnetic secular variation, expressed by an apparent periodicity of about 500 years. Considered in relation to relevant investigations by Bullard, Elsasser, Vestine and others, the model gives rise to some hypothetical conclusions as to the nature and origin of the Earth's interior magnetic field. Despite its mainly analytical foundation, the model provides a material basis for the exact definition and computation of an improved "normal (planetary) geomagnetic field." Finally, the possibility of a rough prediction of this "normal field" for future epochs is considered. A.

550.384/.385

3128. New observations of very rapid pulsations during a magnetic storm. G. GIBAULT. *C.R. Acad. Sci.* [*Paris*] **233**, 1655–6 (*Dec.* 19, 1951) *In French.*

On three occasions very rapid pulsations of the magnetic elements have been observed at Chambon-la-Forêt. On the last it was possible to estimate the period to be of order 6 seconds. The pulsations do not appear to be due to meteorological, atmospheric electric or seismological causes, but are probably associated with magnetic storms. Further investigations at several stations using rapid registration magnetometers are required. A. T. PRICE

550.384 : 523.75

3129. Geomagnetic solar flare effects at Lerwick and Eskdalemuir, and relationship with allied ionospheric effects. D. H. MCINTOSH. *J. Atmos. Terr. Phys.*, **1**, 315–42 (*No.* 5–6, 1951).

The geomagnetic effects of solar flares occurring at Lerwick and Eskdalemuir over the period 1936–49 are identified and tabulated. The annual and daily variations of occurrence and magnitude of these effects are shown to exhibit interesting features, many of which are found to be shown also by short-wave radio fade-outs. The geomagnetic effects are compared in detail with the movements normally proceeding on quiet days at the same time: the H and D components point strongly to the conclusion that the geomagnetic flare and "normal quiet day" (S_q) effects are produced by the same direction of ionospheric current, but the V components indicate that there are substantial differences between the space distribution of the currents in the two cases. The geomagnetic flare effects are found to be less sensitive than any of the other geophysical effects of flares which are examined, and the relative times of start, maximum and end of flares and allied effects are determined. Some difficulties in the explanation of various features shown by the flare effects are discussed. A.

550.389

3130. Magnetic anomalies at high altitudes. I. ZIETZ AND R. G. HENDERSON. *Trans Amer. Geophys. Un*, **32**, 397–404 (*June*, 1951).

To investigate the effect of anomalies in the earth's magnetic field at high altitudes, aeromagnetic maps of two representative areas showing isanomalic curves for total intensity are projected to levels of 10 and 20 miles above the surface of a plane earth. The projections are accomplished by numerical computations and by use of a magnetic-field projecting machine at the Naval Ordnance Laboratory. It is found that anomalies of 500 γ near the surface of the earth, in merging into neighbouring anomalies, may produce effects of 100 γ or more at an altitude of 20 miles. A.

550.463 : 535.434

3131. Optical measurement of particle distribution in the sea. N. G. JERLOV. *Tellus*, **3**, 122–8 (*Aug.*, 1951).

A method has been developed for studying the distribution of suspended particles in the sea. The intensity of the light from a Tyndall beam scattered in the water samples is measured. Essential precautions in the study of clear ocean water are given. The method is illustrated by the particle distribution found off the Nile estuary and in the Strait of Gibraltar. A.

550.837.6

3132. On the screening effect of a conducting layer distributed over the contact region of two media. G. V. MUHINA. *Izv. Akad. Nauk SSSR, Ser. Geogr. Geofiz.*, **14**, 302–16 (1950) *In Russian.*

Replacing the upper horizontal layer of finite thickness h and conductivity k by an ideal plane of conductivity hk it is possible to simplify considerably the computation of the potential due to this layer, the screening effect of which must be eliminated since the purpose of geophysical surveying with the aid of electric methods is the study of tectonic structures beneath the upper alluvial layer. In this paper the simplified problem is solved, the main result being the delimitation of the circular region around the source of current outside of which the error caused by the simplification is negligible. MATHEMATICAL REVIEWS

550.93

3133. The age of the elements. R. L. BURLING. Letter in *Phys. Rev.*, **84**, 839–40 (*Nov.* 15, 1951).

It is argued that the figure of 5×10^9 years obtained from radioactive dating of igneous rocks is an upper limit to the age of the earth's present crust; the "age of the elements" may be as great as 15×10^9 years. M. W. OVENDEN

551.1

3134. Determination of the mean density of the earth from gravity measurements. G. BOAGA AND G. TRIBALTO. *Atti Accad. Naz. Lincei* (*R.C. Cl. Sci. Fis. Mat. Nat.*) **11**, 237–40 (*Nov.*, 1951) *In Italian.*

A Western gravimeter was used to measure the values of gravity at 11 stations inside and 11 stations above a cave in rocks of known density, 2·25 g/cm³. The differences of height were about 60 m and of gravity about 8 mgal. The mean density of the earth was estimated to be $5{\cdot}53 \pm 0{\cdot}014$ g/cm³. A. H. COOK

ATMOSPHERE . METEOROLOGY 551.5

551.508.765

3135. A new method of measurement of cloud-water content. J. WARNER AND T. D. NEWNHAM. *Quart. J. Roy. Met. Soc.*, **78**, 46–52 (*Jan.*, 1952).

A new method of measurement of the liquid-water content of clouds is described. It depends on the change of resistance of a paper tape on being moistened by cloud droplets which impinge directly on it. A continuous and permanent record of the liquid water can be obtained, and variations over distances of a few hundred feet can be detected. Measurements have been made using the technique on a number of cumulus and stratocumulus clouds, some characteristics of which are described. A.

551.510.535

3136. Effects of temperature variations of the upper atmosphere on the formation of ionospheric layers. D. LEPECHINSKY. *J. Atmos. Terr. Phys.*, **1**, 278–85 (*No.* 5–6, 1951).

S. Chapman's well-known theory of ion production by photo-ionization of a gas with an exponentially

decreasing pressure considers the case of a constant temperature. In the present paper a study is made of the effect of an increase of the mean temperature on the distribution of the rate of ion production at various heights. It is shown that at a given height, this rate is extremely sensitive to temperature changes and that it may go through a sharp minimum at midday. The two main effects of a temperature increase being a general elevation of the region where ions are produced and a general decrease of the rate of ion production, an estimate is made of the percentage of temperature increase which one has to assume to explain the higher summer altitude of the F_2 layer at midday as compared with its winter value, and its slight and gradual elevation between 6 a.m. and midday on a summer day. The percentages found (based on Slough 1950 records) are 46% and 21% respectively. It is further shown that the splitting of the F region into F_1 and F_2 may be due to a general temperature increase of the upper atmosphere. The "summer structure" of this region and the critical frequency drop of the F_2 layer during magnetic storms may similarly be considered as an effect of a temperature increase of the gas submitted to the photo-ionization process. It is pointed out that the seasonal variation of the absorption of short waves may also find an explanation in a seasonal temperature variation. A.

551.510.535

3137. Some results of ionospheric measurements made in the neighbourhood of Adélie Land. M. Barré and K. Rawer. *J. Atmos. Terr. Phys.*, **1**, 311–14 (*No.* 5–6, 1951) *In French.*

Ionospheric observations near Adélie Land show many anomalies. F_2-echoes are very often scattered, sometimes to such an extent that they almost disappear, and most F_1- and E-echoes also show some signs of scattering. High values can be attained by selective E-absorption. E_s-echoes are frequently received from several levels at the same time, and echoes, similar to that of E_s, are observed from very high altitudes (1 000 km); all these traces undoubtedly being due to ionic clouds at the E-level. Most of the phenomena observed may be attributed to the proximity of the magnetic pole, which is only 470 km away. Nevertheless, it is only rarely that the quasi-longitudinal z-branch has been observed. A.

551.510.535

3138. Studies on the ionospheric tidal effect. O. Burkard. *J. Atmos. Terr. Phys.*, **1**, 349–52 (*No.* 5–6, 1951) *In German.*

The F_2-layer critical frequencies at Huancayo show a luni-solar daily variation of the same kind as that found in the components of the earth's magnetic field: the semidiurnal lunar variation is pronounced during the day-time only, and is practically absent during the night. Because of the great variability of the individual night-values of fF_2, the phases of the M_2-tide computed for night-hours must be regarded as accidental. A.

551.510.535

3139. An investigation of sudden radio fadeouts on a frequency near 2 Mc/sec. J. W. Findlay. *J. Atmos. Terr. Phys.*, **1**, 367–75 (*No.* 5–6, 1951).

The paper describes the changes of phase path of radio waves returned from region E of the ionosphere during radio fadeouts. Observations of 105 fadeouts have been made on frequencies near 2 Mc/s and it has been possible to determine the collision frequency at the height in the atmosphere where the greatest extra ionization is produced during the fadeout. The collision frequency is of the order of 4×10^5 per sec and corresponds to a height less than 101 km. A.

551.510.535

3140. The nature of the sporadic E layer and turbulence in the upper atmosphere. R. Gallet. *C.R. Acad. Sci.* [*Paris*] **233**, 1649–50 (*Dec.* 19, 1951) *In French.*

It is suggested (*a*) that the E_s-layer consists of diffuse clouds of ionization rather than a thin homogeneous layer and (*b*) that the main body of E_s ionization is produced by turbulence within the normal ionization already present at that level and that the contributions of sources such as meteors is only of secondary importance. W. J. G. Beynon

551.510.535 : 525.6

3141. Solar tides in the ionosphere over Calcutta. A. P. Mitra. *J. Atmos. Terr. Phys.*, **1**, 286–95 (*No.* 5–6, 1951).

The ionospheric data for the F_2-region over Calcutta for the period January 1946 to January 1950 are analysed with a view to determine the amplitude and phase of solar tidal drifts (both semi-diurnal and seasonal), to explain the anomalous ionization changes of the F_2-region and to determine the values of the recombination coefficient in summer and in winter. Martyn's mathematical analysis on ionospheric tides has been extended for this purpose. It is found that: (i) The resultant drift velocity at Calcutta is 12 km/hr in both summer and winter, and 17 km/hr in the equinoxes, being maximum downwards at 1 630 in summer, at 1 500 in the equinoxes and at 1 330 in winter; (ii) the observed anomalous variations of F_2 ionization, both in night and in day-time, are explained taking into account the effects of both recombination and tidal drifts; (iii) the calculated values of the coefficient of recombinations are all of the order of 10^{-11} cm/sec. A.

551.510.535 : 537.56

3142. The determination of the collision frequency of electrons in the ionosphere from observations of the reflection coefficient of the abnormal E layer. B. H. Briggs. *J. Atmos. Terr. Phys.*, **1**, 345–8 (*No.* 5–6, 1951).

Observations of echoes received simultaneously from the abnormal E-layer and from the F-layer enable the reflection coefficient and transmission coefficient of the abnormal E-layer to be measured. These quantities are recorded as functions of frequency. On some occasions the results are consistent with the assumption that the abnormal E-layer consists of a thin horizontally stratified layer of ionization with a total thickness of the order of 5 km. From the absorption which is found to occur for frequencies near the critical frequency, it is possible to deduce the collision frequency of electrons at a well-defined height in the atmosphere. Some typical results are given. A.

551.510.535 : 538.566.3

3143. The phase and group paths of radio waves returned from region *E* of the ionosphere. J. W. FINDLAY. *J. Atmos. Terr. Phys.*, **1**, 353–66 (*No.* 5–6, 1951).

Equipment is described which has been used to measure the changes of phase path of radio waves of frequency 2·4 Mc/s returned from region *E* of the ionosphere. It is shown that the daily variation of phase path cannot be explained quantitatively on the assumption that region *E* behaves as a simple Chapman region, although there is qualitative agreement with the theory. The seasonal changes of noon values of the group path are studied and found to disagree with those predicted for a Chapman region. Some evidence for the existence of a solar tide in the height of region *E* is given. A.

551.510.535 : 538.566.3

Radio-wave propagation in the ionosphere. *See Abstr.* 2857, 2860–1

551.511

3144. On the energy balance of the atmosphere. R. M. WHITE. *Trans Amer. Geophys. Un*, **32**, 391–6 (*June*, 1951).

The net radiative energy surplus or deficit of the atmosphere in middle and high latitudes is inferred from a consideration of energy transport processes in the atmosphere. It is shown that the results are consistent with estimates made through direct consideration of the radiative processes, thus providing an independent check upon them. A.

551.521

3145. On the effective radiation to various parts of a cloudless sky. O. LÖNNQVIST. *Tellus*, **3**, 148–53 (*Aug.*, 1951).

From the author's formula [Abstr. 6901 (1950)] for the relative radiation as a function of temperature and humidity conditions in the atmosphere, a formula is deduced for the zenith distance variation of the effective radiation. This formula is compared with observational data and empirical formulae. Finally, the constancy of the representative zenith distance, for which the effective radiation equals the effective radiation integrated over the whole hemisphere, is investigated. A.

551.524 : 536.2.02

A problem in atmospheric diffusion. *See Abstr.* 2660

551.556 : 525.6 : 525.35

The effect of winds and tides on the length of the day. *See Abstr.* 2398

551.574

3146. A basic question concerning condensation processes in the atmosphere. L. KRASTANOW. *C.R. Acad. Bulg. Sci.*, **3**, 13–16 (*Jan.–March*, 1950) *In German.*

The physical-chemical properties of the outer surface of a condensation nucleus decides whether a film of condensed water vapour may form on it in unsaturated water vapour or a certain degree of supersaturation may be required. It then acts as a nucleus with the radius of the water envelope according to the Thomson–Gibbs equation. Less work is then performed in the formation of the nucleus. Expressions are obtained, with the help of Becker and Döring's method for a system of water vapour and wet condensation nuclei, for the rate of formation of wet condensation nuclei and the work done at formation. It is considered also that the longer a certain degree of supersaturation is maintained the greater is the chance of formation of nuclei. R. S. READ

551.574.1

3147. Effect of turbulence and condensation on drop-size distribution in cloud. A. C. BEST. *Quart. J. Roy. Met. Soc.*, **78**, 28–36 (*Jan.*, 1952).

Equations are developed to represent the rate of change of the number of drops of a given size in a cloud owing to condensation and to coalescence respectively. Numerical computation from these equations shows that condensation has a much greater effect than coalescence on drop-size distribution in clouds with small average drop size, with small liquid-water content or with a large degree of supersaturation. With the assumption that drop-size distribution in a cloud is governed by rate of condensation on the drops in the cloud and rate of turbulent diffusion of the drops out of the cloud it is then shown that the fractional volume of water comprised by drops smaller than a specified size is expressible in terms of an Incomplete Gamma function. In this Incomplete Gamma function the argument is 1·5 and the upper limit to the integral varies as the square of the drop size and is also proportional to a quantity which depends upon the degree of turbulence and upon parameters connected with the rate of condensation. It is shown that this theoretical formula approximates closely to a simpler formula already established empirically and that reasonable values for the coefficient of turbulence and the condensation parameters lead to a mean drop size which agrees closely with measured values. A.

551.574.1 : 536.421.4.031

3148. The spontaneous crystallization of supercooled water. B. J. MASON. *Quart. J. Roy. Met. Soc.*, **78**, 22–7 (*Jan.*, 1952).

It is shown theoretically that the rate of nucleation of the ice phase in supercooled water changes very rapidly with temperature in the neighbourhood of −40°C. Thus, in chilling a supercooled water cloud below this temperature one would expect to observe a rapid increase in the number of ice crystals which appear as the temperature falls. This is verified by observations made in a cold chamber. The different critical temperatures for the spontaneous appearance of ice crystals quoted by Schaefer (−39°C) and the Oxford workers (−41°C) probably arise as the result of differences in the experimental conditions. It is tentatively suggested that the parts of mother-of-pearl clouds showing iridescence at temperatures around −80°C consist of spheres of "glassy" ice, which may eventually crystallize spontaneously to form ice crystals towards the leeward edges of the cloud. A.

551.576

3149. A new method of stimulating convective clouds to produce rain and hail. E. G. BOWEN. *Quart. J. Roy. Met. Soc.*, **78**, 37–45 (*Jan.*, 1952).

The theory of the formation of rain by coalescence leads logically to the suggestion that, if water drops of suitable size are sprayed into the base of a convective cloud, the drops will ascend in the upward air

current, will grow by coalescence with the cloud droplets and may ultimately fall out as rain. Calculations show that under appropriate conditions the drops could attain a diameter greater than 1 mm and emerge from the base of the cloud from 20 to 60 min after water had been sprayed into it. Eleven experiments have been carried out to test the possibility of the method. In 10 cases, distinct changes occurred following the introduction of a water spray into the selected cloud. In 4 of these, virga fell from the cloud and it dissipated soon afterward. In 4 cases, rain or hail appeared shortly after spraying. On only one occasion were no results observed. The results suggest that the method might be useful for the artificial stimulation of rainfall, but further experiments are required to establish the mechanism fully. A.

551.577

3150. A vertical shaft for the production of thick artificial clouds and for the study of precipitation mechanics. R. GUNN. *J. Appl. Phys.*, **23**, 1–5 (*Jan.*, 1952).

Progress in cloud physics has been seriously limited because of the impossibility of conducting controlled cloud experiments on a sufficiently large scale. To meet the requirements, a laboratory has been built in which thick artificial expansion type clouds may be produced under controlled and measurable conditions. A mine shaft 0·210 km deep and 2·2×2·2 m in cross-section has been sealed and adapted to the production of thick artificial clouds. The shaft and its principal auxiliaries necessary for the study of some of the basic problems of clouds and precipitation are described. Dense, thick clouds completely filling the shaft are now being produced on a routine basis. Some preliminary illustrative data are presented. A.

551.578.1 : 533.6

Free fall of drops through air. *See Abstr.* 2480

551.590.22

3151. Research on a possible influence of the moon on atmospheric precipitation. H. MINEUR. *C.R. Acad. Sci.* [*Paris*] **233**, 1426–8 (*Dec.* 3, 1951) *In French.*

Records of rainfall over a 75 yr period at 3 widely-separated stations reveal a correlation between lunar phase and precipitation. A fourth station does not show a lunar effect. Phase of the relationship varies with locality, and appears independent of oceanic tidal influence. D. R. BARBER

551.593.5

3152. The blue sun of 1950 September. R. WILSON. *Mon. Not. Roy. Astron. Soc.*, **111**, 478–89 (*No.* 5, 1951).

Spectrophotometric observations of the "blue" and normal suns give an extinction curve of the layer causing the phenomenon. This covers the wavelength range of 3 800–6 300 Å, and shows blueing on the long wavelength side, and reddening on the short wavelength side, of a minimum situated at λ4350. This affords an experimental verification of an outstanding feature of scattering theory. It is concluded that the scattering particles producing the minimum are dielectric, and uniform in size and constitution. A relation between the size and refractive index of the dielectric particles is deduced. In addition to the selective effect, there is a heavy non-selective extinction which may arise from another system of absorbing particles in the layer. Other workers have established the source of the layer as the extensive forest fires burning in Alberta on September 23, 1950. A.

551.593.5

3153. The "blue sun" phenomenon. W. JENNE. *Tellus*, **3**, 129–34 (*Aug.*, 1951) *In German.*

The "blue sun" phenomenon could be observed in Scotland September 26, 1950, and in other parts of Europe, for instance in Sweden and Germany, on the following day. An attempt was made approximately to fix the probable geographical limits inside of which the bluish colour of the sun could be seen. The investigation deals also with the explanation of the phenomenon from the point of view of theoretical physics. A.

551.593.5

3154. The blue sun of September 1950. A. ÅNGSTRÖM. *Tellus*, **3**, 135–40 (*Aug.*, 1951).

Two causes for a coloured sun are discussed, namely refraction and absorption. The importance of integrating the refraction effects arising from different parts of the sun's disk as light sources is emphasized. It is shown that by such integration of ring phenomena around the sun, many observed peculiarities may be explained. Important conditions that some types of coloured suns shall arise are homogeneity of the particles of the scattering medium, and also that the particles shall be large enough to give rise to rings of sufficiently small radius. Transfer of air masses at long distances but without sideward mixture taking place is in favour of the creation of dust sheets of homogeneous character, as vertical sedimentation has then time to come into action. A.

551.593.9

3155. Measurements of the ultraviolet radiation of the night sky. S. F. RODIONOV AND E. N. PAVLOVA. *Dokl. Akad. Nauk SSSR*, **79**, 961–4 (*No.* 6, 1951) *In Russian.*

Presents the results of an investigation on the variations of the night-sky radiation and its distribution on the sky-vault. Self-quenching photon counters were used; the wavelength ranges investigated were 290–360 and 295–390 mμ. It is claimed that the part played by diffuse sunlight is small compared with the emission of the atmosphere itself. F. LACHMAN

551.593.9 : 535.338.3

3156. Relative intensity of the two components of the Na doublet in the light of the night sky. P. BERTHIER. *C.R. Acad. Sci.* [*Paris*] **234**, 233–4 (*Jan.* 7, 1952) *In French.*

Photographic photometry of the Fabry–Perot interferometric pattern obtained on dry, clear winter nights gives an intensity ratio, $D_2/D_1 = 1{\cdot}98 \pm 0{\cdot}05$, in agreement with theoretical value, 2·0. Further work will examine whether or not the ratio is reduced on humid nights by the masking effect of H_2O absorption on the D_2 line at 5 890 Å. D. R. BARBER

551.594.14

3157. Researches on the radioactivity at the summit of the Puy de Dôme. H. GARRIGUE. *C.R. Acad. Sci.* [*Paris*] **233**, 1447–8 (*Dec.* 3, 1951) *In French.*

Investigations are being made of the radioactivity

of the atmosphere using a ground station at 1 465 m and also an aeroplane. The present note is chiefly concerned with the study of the radioactivity of freshly precipitated snow which was found to be radioactive with a period of approximately 10 days. J. M. HOUGH

551.594.14 : 541.182.3

3158. Natural radioactivity as a tracer in the sorting of aerosols according to mobility. M. H. WILKENING. *Rev. Sci. Instrum.*, **23**, 13–16 (*Jan.*, 1952).

Natural radioactivity in the atmosphere is used as a "tracer" in the study of aerosol particle-size distribution in the submicroscopic range. Particulate matter is collected by a device which first ionizes the particles and then separates them according to their mobilities. The results indicate that most of the natural radioactivity in the atmosphere attaches itself to particles having diameters in the range 0·001 to 0·04 micron. A predominant grouping of the activity occurs in the vicinity of two particle diameters: 0·009 and 0·018 micron. The relationship between the distribution of radioactivity and the abundance of particles in different size ranges is discussed. A.

551.594.222

3159. Point-discharge currents and the earth's electric field. W. C. A. HUTCHINSON. *Quart. J. Roy. Met. Soc.*, **77**, 627–32 (*Oct.*, 1951).

An account is given of measurements of the current flowing to earth through a point set up at a height of 12 m, together with the electric field near the ground. Point-discharge current of either sign may be represented approximately as increasing with the square of the field, as found by Whipple and Scrase. In the light of recent work on corona discharges between a point and a plane in air at atmospheric pressure it is suggested that for high fields the point-discharge current will vary directly as the field. Irregularities in the curves relating averages of discharge current and field are attributed to space charge arising from local point discharge at or near the raised apparatus used for measuring the field. An advancement of field changes ahead of the corresponding point-current changes is considered to be an example of the reversal, by space charges, of the sign of field between the level of a raised point and the ground, described by Lutz. A.

551.594.5

3160. A photographic study of changes of the infrared emission of the polar aurora. L. HERMAN AND H. LEINBACH. *Trans Amer. Geophys. Un*, **32**, 679–82 (*Oct.*, 1951).

Pairs of pictures of the aurora taken simultaneously on a panchromatic film through a green filter and on an infrared film through a red filter sometimes show a striking enhancement of the infrared emission with the passage of time. The paper gives the results of a semi-quantitative comparison of two different sequences of such pictures, made at College, Alaska. A.

551.594.9 : 538.561

Ionospheric thermal radiation at radio frequencies. *See Abstr.* 2849

551.596

3161. Acoustical energy generated by the ocean waves. F. B. DANIELS. Letter in *J. Acoust. Soc. Amer.*, **24**, 83 (*Jan.*, 1952).

An estimate of the order of magnitude of the acoustical energy generated by ocean waves indicates that this energy is large enough to cause an appreciable heating effect at ionospheric levels, where most of it is absorbed. Using data obtained from surface measurements of the pressure amplitude, it is found that relative density changes of the order of 1% occur at ionospheric levels, and the suggestion is made that the "twinkling" of cosmic sources of radio waves is a result of this phenomenon. A.

551.596 : 551.510.4 : 538.562

3162. Acoustic characteristics of the atmosphere. G. ECKHART. *Rech. Aéronaut., No.* 21, 59–66 (*May–June*, 1951) *In French.*

The author considers the properties of a stratified atmosphere, i.e. one whose pressure, temperature and relative humidity are functions only of the height above the surface of the earth. The major portion of the paper is devoted to statements, formulae, graphs and tables showing the effects of temperature and relative humidity on the velocity, characteristic impedance and attenuation of sound waves in air. It is a useful summary of this information. The author also presents information on the effects of temperature and humidity on the propagation of electromagnetic waves. He points out that whereas changes in temperature are much more significant than changes in humidity with regard to sound propagation, the reverse is true in the electromagnetic case. The author suggests that simultaneous observations of acoustic and electromagnetic transmissions in the atmosphere may yield useful information about its composition at any given time and place. APPLIED MECHANICS REVIEWS

551.596.1 : 551.571

3163. Absorption of acoustic waves in humid air and fog. V. I. ARABADZYL. *Met. i Gidrolog., No.* 3, 11–18 (1947) *In Russian.*

The paper contains a survey of the present state of knowledge of the theory of absorption of sound waves in clouds and fog. Size of water drops in the atmosphere, frequency of sound waves being propagated and chemical composition, as well as sound and zones of silence, are discussed. METEOROLOGICAL ABSTRACTS

BIOLOGY 57/59

578

3164. Technique for exposing grasshopper neuroblasts to beta-rays. M. E. GAULDEN, C. W. SHEPPARD AND H. CEMBER. *Nature* [*Lond.*] **169**, 228–9 (*Feb.* 9, 1952).

The β-ray source is a 3 in plate of a bakelite-P^{32} compound; it is calibrated in an extrapolation chamber whose polystyrene electrodes have similar scattering properties to those of the grasshopper embryos and the container in which they are afterwards irradiated. The radioactive plate is then placed in a protected holder which moves in a slide under an

exposure dish containing the neuroblasts. This dish is formed by "Lucite" rings clamping a 0·001 in membrane on to which the dissected embryo is mounted direct. Dosage correction is made for absorption in this membrane. Exposure time can be controlled accurately. Emphasis is laid on the many protection devices employed. A detailed description of the apparatus, and an "exploded" drawing, are given. D. V. MABBS

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.014.462.481

3165. A suggested chain process for radiation damage. A. T. REID AND H. G. LANDAU. *Bull. Math. Biophys.*, **13**, 153–63 (*Sept.*, 1951).

It has been suggested that when an organism is exposed to ionizing radiation the initial damage results from the occurrence of ionization in a so-called sensitive volume due to absorption of radiation quanta. The initial radiation damage is then transmitted or amplified to a level of macroscopic perception. A mechanism by which this transmission may take place and a finite Markov chain model applicable to this transmission are postulated and discussed. A.

612.014.462.481

3166. A physical investigation of heat production in human tissues when exposed to microwaves. H. F. COOK. *Brit. J. Appl. Phys.*, **3**, 1–6 (*Jan.*, 1952).

Experimental investigations of temperature rises produced in parts of the human body during exposure to microwaves of 10 and 9·4 cm wavelength are described. Application of linear heat flow theory shows that the experimental skin temperature rise in the initial stages of a microwave exposure is consistent with a thermal conductivity for tissues of 0·005 cal m^{-1} sec^{-1} $°C^{-1}$. With occlusion of the blood supply to the irradiated region the conductivity remains at this value until the pain threshold is reached. With no occlusion, increase in blood supply due to heating causes the effective conductivity to rise during exposure, but the theory becomes inapplicable as soon as heat flow is non-linear. Comparison is made of theoretical and experimental subcutaneous and muscle temperatures after microwave exposure and the differences explained. The influence of wavelength variation and air-cooling of the skin are discussed. A.

612.014.462.481 : 535.23

3167. The absorption of human skin between 430 and 1 010 mμ for black-body radiation at various colour temperatures. R. R. HEER, JR. *Science*, **115**, 15–18 (*Jan.* 4, 1952).

This is an investigation into the max. expected absorption of normal and tanned skin of white people and negroes. Colour temperatures of up to 15 000°K are considered. This range refers to radiations emitted from the fire ball of atomic explosions. The absorption for the average tanned skin of energy at any colour temperature within the above range of wavelengths is almost identical for white and black faces, and varies only insignificantly for untanned skin (approx. 5%). With the absorption for 2 000°K taken as unity, absorption increases by a factor of 10 at 2 700°K, of 100 at 3 900°K, of 1 000 at 6 200°K, and of 10 000 at 14 000°K. W. SUMMER

612.85

3168. The time in which equilibrium state of audition is established. I. The damping constant of the inner ear. II. The time constant of building up or decay of auditory sensation at the threshold. III. A new method of measuring the damping constant of the mechanical system of the ear. Y. MAKITA AND S. MIYATANI. *Mem. Res. Inst. Acoust. Sci. Osaka*, **1**, 6–19, 38–42 (*Feb.*, 1950).

612.85

3169. Compressive properties of the hearing organ. H. MOL. *Tijdschr. Ned. Radiogenoot.*, **16**, 277–90 (*Nov.*, 1951) *In Dutch.*

It is shown that the enormous dynamic range of the ear is the result of the compressive action of the ossicle chain, which is regulated by the stapedial muscle. The dynamic spread of normal ears is caused by individual deviations of the compressive mechanism. A.

612.85

3170. Theory of perception. On the elements of spatial perception in microphone audition. A. MOLES. *C.R. Acad. Sci.* [*Paris*] **233**, 1583–5 (*Dec.* 19, 1951) *In French.*

In the transmission of sound by two separate channels, the spatial perception element is the minimum distance between two positions of a sound source, which can be detected by the listener. Tests are reported which show that this is of the order of 1 to 2 m in a normal room. G. F. HODSMAN

612.85

3171. D.C. resting potentials inside the cochlear partition. G. V. BÉKÉSY. *J. Acoust. Soc. Amer.*, **24**, 72–6 (*Jan.*, 1952).

Inside the cochlear partition there is without any acoustical stimulus a d.c. potential difference between the organ of Corti and the endolymph of the order of 100 mV. The possible significance of this potential difference has been pointed out. The magnitude of the potential difference seems to indicate that the cochlear partition represents a pool of energy. A.

612.85

3172. Frequency discrimination for damped waves. K. N. STEVENS. *J. Acoust. Soc. Amer.*, **24**, 76–9 (*Jan.*, 1952).

Measurements of frequency discrimination for single damped waves are reported for frequencies between 200 and 5 000 c/s, and for values of the damping σ between 0 and 500 sec^{-1} (σ is the reciprocal of the time constant of the envelope of the damped wave). There is an increase in the difference limen for frequency as the damping increases, or as the effective duration decreases. The increase in the difference limen is accompanied by a loss in the pitch character of the stimulus, and there is usually a sharp deterioration in discrimination above a certain value of damping, i.e. above a certain bandwidth of the stimulus. The results are related to existing data on the perception of short sinusoidal stimuli. A.

612.85

3173. A loudness chart for octave-band data on complex sounds. F. MINTZ AND F. G. TYZZER. *J. Acoust. Soc. Amer.*, **24**, 80–2 (*Jan.*, 1952).

The equivalent-tone method of Beranek, Marshall, Cudworth and Peterson has been used as a basis for developing a loudness chart for octave-band data on noise. The loudness chart consists of contours of equal pressure level in octave bands which are superimposed on a loudness grid. The procedure is based on octave-band data, since octave-band filter sets are readily available commercially and are being widely used in noise measurement. Good agreement is shown with loudness values for various noises determined by Beranek *et al.*, using 300 and 600 mel bands, and there is, therefore, good agreement with existing psychological data. The loudness chart not only facilitates the calculation of loudness but provides graphical loudness curves for comparison of noise and for the evaluation of various noise reduction measures. A.

612.85 : 534.321.4

Differential sensitivity of harmony. I. *See Abstr.* 2546

614.898

3174. The hazards of radiation. A. E. HEUSTIS AND D. VAN FAROWE. *Radiology*, **57**, 832–6 (*Dec.*, 1951).

A report is given of a survey of radiation dose to the staff in the X-ray diagnostic department of 11 state mental hospitals in Michigan over a period of one month. A hazardous radiation exposure was found to exist in some of these. Recommendations for the reduction of these hazards are made. H. MILLER

614.898

3175. A potential source of danger: the emission of X-rays from rectifying valves in X-ray therapy units. R. E. ELLIS AND L. H. S. CLARK. *Brit. J. Radiol.*, **25**, 17–18 (*Jan.*, 1952).

It is shown that the valves in a constant-potential X-ray generator may emit X-rays from their cathode assemblies. Radiation levels of up to 0·32 r/hr at 1 metre, with a H.V.L. of 2·3 mm Al, have been observed. The intensity of stray radiation falls during continuous working of the set. D. V. MABBS

615.849

3176. Two million volt roentgen therapy. J. G. TRUMP, K. A. WRIGHT, W. W. EVANS, H. F. HARE AND S. W. LIPPINCOTT, JR. *Amer. J. Roentgenol. Radium Ther.*, **66**, 613–23 (*Oct.*, 1951).

Physical characteristics of a 2 MeV Van de Graaf unit are studied using photographic film, and dosage distributions are given for a single field and for rotation around the tumour centre. The results are compared with 250 kV therapy, and dosage levels for typical cancer treatments are given. F. T. FARMER

615.849

3177. The design of wedge filters for X-ray therapy. A. C. GROOM. *Brit. J. Radiol.*, **24**, 676–81 (*Dec.*, 1951).

An examination of the dose distributions produced by copper wedge filters of the plateau type has been made for a variety of wedge shapes and field sizes at 226 kV. Empirical formulae are given for construction of wedge filters giving optimum conditions for use in normal deep therapy. H. MILLER

615.849

3178. A note on the dosimetry of grid fields. B. M. WHEATLEY AND B. W. WORTHLEY. Letter in *Brit. J. Radiol.*, **24**, 692 (*Dec.*, 1951).

A simple determination of X-ray dosage with a grid interposed between the tube and the patient. F. T. FARMER

615.849

3179. 1000-curie cobalt-60 units for radiation therapy. H. E. JOHNS, L. M. BATES, E. R. EPP, D. V. CORMACK AND S. O. FEDORUK; A. MORRISON, W. R. DIXON AND C. GARRETT. Letter in *Nature [Lond.]* **168**, 1035–6 (*Dec.* 15, 1951).

Preliminary details are given of two units for radiation therapy in which a 1 000-curie source of Co^{60} is enclosed in a well-shielded head. Adjustable diaphragms give field sizes over the normal range at 1 metre source-to-skin distance. The depth doses measured in water with these units are compared with published depth dose data from X-ray units at 2 MeV and 3 MeV. It is concluded that the average photon energy in the Co^{60} unit is comparable with the 3 MeV X-ray unit. H. MILLER

615.849

3180. Microwaves in medical and biological research. J. E. ROBERTS AND H. F. COOK. *Brit. J. Appl. Phys.*, **3**, 33–40 (*Feb.*, 1952).

Recent work on the absorption of microwave radiation in the frequency range 10^9 c/s to 3×10^{10} c/s is reviewed, with particular reference to materials of biological interest. The relative importance of ionic conduction, dipolar relaxation, particularly of water molecules, and resonance is discussed briefly. Conventional methods for dielectric constant and loss measurements at microwave frequencies can be adapted for use with biological materials and a number of such modifications are described. The results of investigations into the dielectric properties of water, the most abundant biological material, proteins and a variety of body tissues are outlined and discussed in terms of established dielectric theory. High-power microwave generators have been used to study tissue heating, the heating pattern comparing favourably with predictions from the radiation propagation constants and the thermal properties of the materials. A few experiments on the effects of microwaves on animal tumours and on viruses are described. A.

TECHNICAL MATERIALS 66/67

66

3181. Chemical engineering materials of construction. *Industr. Engng Chem.*, **43**, 2193–2294 (*Oct.*, 1951).

A review of recently published material on properties and applications in chemical engineering. Each article is separate with its own bibliography; special data tables are given for some materials. Sections: Aluminium alloys; Carbon and graphite (data table); Cements (data table); Ceramics; Wrought copper and copper-base alloys; Elastomers; Fibres; Iron, mild steels, and low-alloy steels; Nickel and high-nickel alloys; Paint; Hard rubber; Stainless steel and other ferrous alloys (data table); Tin and its alloys (data table); Wood (data table); Less common metals.

PHOTOGRAPHY 77

77.023.4 : 778.34

3182. The development of Ilford G5 emulsion with ID19 developer. A. J. HERZ. *J. Sci. Instrum.*, **29**, 15–18 (*Jan.*, 1952).

A quantitative investigation has been made for a range of temperatures and developing times, using the temperature cycle method. Background grain densities below 1 grain/1 000 μ^3 have been found to be obtainable for temperatures up to 22°C if the duration of the warm stage is sufficiently short (15 to 20 min at 22°C). The average temperature coefficient of the minimum grain density between 14°C and 22°C is about 5% per °C. The factors affecting uniformity of development have been investigated by a new technique in which the depth of penetration and the degree of development occurring in the cold stage are measured as separate quantities. It is concluded that ½-strength ID19 is not a satisfactory developer for emulsion thicknesses above about 200 μ. A.

771.3

3183. Studies in the resolving power of photographic emulsions. III. The effect of the relative aperture of the camera lens on the measured value. F. H. PERRIN AND J. H. ALTMAN. *J. Opt. Soc. Amer.*, **41**, 1038–47 (*Dec.*, 1951).

For Pt II, see Abstr. 4979 (1951). It was found experimentally that, as the relative aperture of the camera lens increases, the lens being substantially "perfect," the measured value of the resolving power of an emulsion used with it also increases, but eventually attains a maximum and then decreases. It is proposed to call this maximum the "maximum lenticular" resolving power of the emulsion. A hypothetical relation is derived for predicting the measured resolving power of a lens-emulsion combination for the maximum lenticular resolving power of the emulsion and the resolving power of the lens on the Rayleigh criterion, assuming the lens to be "perfect." A.

771.534

3184. Superposition or mixture of simple quantic characteristic curves of photographic emulsion layers. The corresponding relative contrast. L. SILBERSTEIN. *J. Franklin Inst.*, **252**, 309–26 (*Oct.*, 1951).

An account is given of mathematical methods for computing certain significant points (of inflection) in the superposition of two or more curves. A knowledge of these points leads to the value of the relative contrast. The curves give the photographic density as a function of exposure. L. S. GODDARD

771.535

3185. On the theory of the Sabattier effect. V. Can the theory developed for Sabattier layers also be applied to normal layers? The thermal Sabattier effect. H. ARENS. *Z. wiss. Photogr.*, **46**, 125–34 (*No.* 7–9, 1951) *In German.*

A continuation of former work [Abstr. 7497–8 (1949), 3655, 6927 (1950)]. Application of the earlier theory to normal negative layers proves unsatisfactory. To obtain further information experiments have been made on the thermal Sabattier effect (heating instead of illumination after the first development), and the relation between time of pre-development and log of heating time plotted for various values of the expression $A = (G-S_{min})/G$, where G is the blackening of a region not pre-illuminated and S_{min} the min. of the Sabattier curve. The contours so produced were compared with those for the ordinary Sabattier effect. The thermal effect was particularly well shown by glycin developer, while both effects were intensified by addition of Na_2SO_3 or $Na_2S_2O_3$ though not by KI. The phenomena are discussed in terms of the theory of Stevens and Norrish. S. T. HENDERSON

778.3

3186. On loading nuclear emulsions with wires. M. DANYSZ AND G. YEKUTIELI. Letter in *Phil. Mag.*, **42**, 1185–6 (*Oct.*, 1951).

The distortion in a nuclear emulsion introduced by the presence of wires can be almost completely eliminated by arranging for the release of the slight tension the wires have when first placed in the newly coated emulsion, and by introducing a resin into the emulsion after processing which prevents the emulsion from shrinking on drying. A. C. COATES

778.3

3187. Grain density fluctuations in photographic emulsions. P. E. HODGSON. *Brit. J. Appl. Phys.*, **3**, 11–13 (*Jan.*, 1952).

The fluctuations of the number of grains in successive sections of tracks produced by charged particles in nuclear research emulsions have been investigated. It is shown that the observed departures from the expected Poisson distribution can be attributed to close pairs of grains remaining unresolved, and that the standard deviation of a grain count is about three-quarters of the square root of the total number of grains counted. A.

778.33

3188. A new high-resolution system of autoradiography. H. J. GOMBERG. *Nucleonics*, **9**, 28–43 (*Oct.*, 1951).

A wet process in which a very thin layer of silver bromide in collodion (~1 μ thick) is coated over the surface of the specimen to be studied. The collodion layer is applied by dipping the specimen into a solution of collodion in alcohol containing Cd and NH_4 bromides. The specimen is kept in silver nitrate solution (containing sufficient H_2SO_4 to give a *p*H of 2·5) in a refrigerator throughout the period of exposure. It is then removed and transferred to the developer, at room temperature, consisting of silver nitrate, ferrous sulphate alcohol and acetic acid in distilled water. During the development Ag grains grow around sensitivity specks, the final grain size (0·2 to 10 μ) depending on the acetic acid solution. Refrigeration of the collodion and the silver nitrate solutions during processing and exposure, and also the H_2SO_4, help to suppress fog. It is sometimes necessary to introduce a very thin protective coating between the specimen and the collodion layer to prevent direct chemical interaction. Suitable substances for this purpose are described. 1 μ resolution is possible. L. R. SHEPHERD

778.33

3189. Tritium in radioautography. P. J. FITZGERALD, M. L. EIDINOFF, J. E. KNOLL AND E. B. SIMMEL. *Science*, **114**, 494–8 (*Nov.* 9, 1951).

Using nuclear track plates, a resolution of 2·5 μ is obtained. Beta-tracks are difficult to trace individually. Alpha-emitters are biologically foreign. H^3 has high biological affinity to the micro-organisms and a very limited range (6 μ; $\beta - 17{\cdot}9$ keV). The method and technique of labelling and preparing paramaecia and yeast cells (Torula utilis) are described. The half-life of $H^3 = 12{\cdot}1 \pm 0{\cdot}5$ yr. W. SUMMER

778.33

3190. A technique for preparing beta-ray autoradiographs of metals and minerals. A. B. MICHAEL, W. Z. LEAVITT, M. B. BEVER AND H. R. SPEDDEN. *J. Appl. Phys.*, **22**, 1403–6 (*Dec.*, 1951).

A technique for preparing autoradiographs of metals and minerals on a microscale is described. Limitations of this technique and possible variations are indicated. Illustrative examples of autoradiographs are presented and interpreted. A.

778.33 : 539.185

3191. Neutrons in autoradiography. Lithium doses in embryos of amphibians. A. FICQ. *C.R. Acad. Sci.* [*Paris*] **233**, 1684–5 (*Dec.* 19, 1951) *In French.*

LiCl exercises a toxic and inhibitory effect on the morphogenesis of an amphibian embryo. Autoradiographic methods have been used to discover and study the distribution of Li in the organism.

W. SUMMER

778.34

3192. Use of the microdensitometer for the study of nuclear films. M. ADER, J. DEBIESSE, T. KAHAN AND L. ROUGEOT. *C.R. Acad. Sci.* [*Paris*] **233**, 1446–7 (*Dec.* 3, 1951) *In French.*

A method is described for the rapid determination of the spatial distribution of nuclear particles by photographic density measurements. A. C. COATES

778.37

3193. Discrete photograph of an ultra-speed event with General Radio camera. W. A. ALLEN AND J. S. RINEHART. Letter in *Rev. Sci. Instrum.*, **22**, 1020 (*Dec.*, 1951).

A burning Al pellet moving at 15 000 ft/sec was photographed on a continuously moving film, with a very fine slit in the field of view instead of in the focal plane. S. T. HENDERSON

778.37 : 537.523.4

3194. The electrical and luminous characteristics of short air sparks suitable for high speed photography. W. G. STANDRING AND J. S. T. LOOMS. *Proc. Phys. Soc.* [*Lond.*] *B*, **65**, 108–15 (*Feb.*, 1952).

The light emitted by various forms of spark gap is examined, and the factors affecting maximum value and variation with time are discussed. Measurements of the voltage drop across the spark help to explain the effects on light output of spark duration and form of spark gap. A rough spectral analysis is given for an open gap. A.

778.37 : 621.383

3195. The application of image converters to high speed photography. J. A. JENKINS AND R. A. CHIPPENDALE. *J. Brit. Instn Radio Engrs*, **11**, 505–17 (*Nov.*, 1951).

After briefly discussing various English and foreign image convertors, the performance of the Mullard ME 1200 series is explained as the result of the newly developed process to make low resistance Cs–Sb cathodes ($\ll$1 000 Ω/cm^2 compared with MΩ/cm^2 for normal Cs–Sb cathodes). The fluorescent screen is Al-backed. Both the willemite and ZnS : Ni screen will resolve 50 lines/mm. The screen diameter is 117 mm. Circuits for operating the image convertor as either a static or dynamic tube are given and records can be obtained for exposures $<$ 1 μsec. It is also possible to move the electron beam across the screen, thus pulsing and scanning the three-electrode ME 1201 simultaneously. Flash-tubes are used as high intensity sources. There are peak intensities up to 250 M lumen. W. SUMMER

778.6 : 535.624

3196. Duplication of color images with narrow-band filters. R. J. ROSS. *J. Soc. Mot. Pict. Televis. Engrs*, **57**, 267–74 (*Sept.*, 1951).

A discussion of the problems involved in making acceptable duplicates of colour films of the direct positive, subtractive type. Each of the three dyes transmits some unwanted light, in particular the magenta dye passes some green. To reduce this effect duplicates have been made by exposure, not to white light, but to three separate narrow bands of red, green and blue light at suitably adjusted relative exposures. Ideally each narrow band should thus produce an image in one layer only of the duplicating film. The results are said to be of a high standard. The necessary variations and control of processing are briefly discussed, also the methods for triple exposure, and the difficulties of evaluation or specification of acceptable duplicates. S. T. HENDERSON